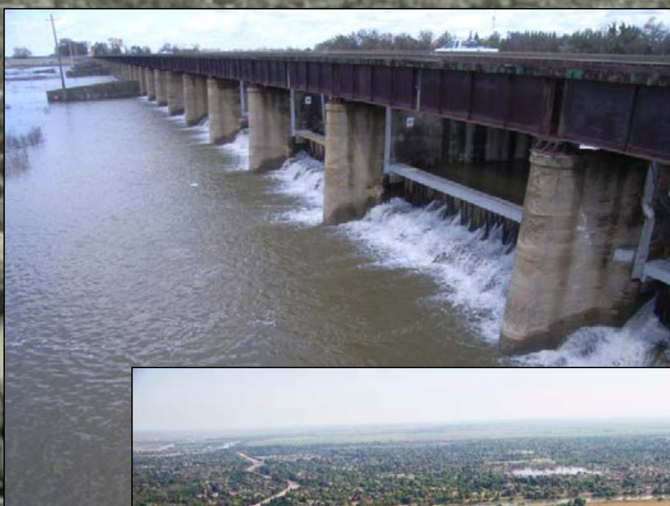
American River Watershed

Common Features
General Reevaluation Report



Final Economics
Appendix E

December 2015

SAFCA
Sacramento Area Flood Control Agency

Central Valley Flood Protection Board
Public Safety and Flood Management
State of California

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:

Sacramento Weir during operation

Sacramento River facing south near the Pocket and Little Pocket neighborhoods

High flows on the American River at the Highway 160 overcrossing

Folsom Dam releasing high flows

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CHAPTER 1
INTRODUCTION

1.1 PURPOSE & SCOPE

This Appendix documents the economic analysis performed for the American River Common Features General Reevaluation Report (ARCGF GRR). The main purposes of this report are to:

- Describe the framework of the economic analysis, including the major assumptions, data, methodologies, and analytical tools used.
- Describe the flood risk, in terms of probability of flooding and consequence of flooding, associated with the without-project condition, which assumes that three previously authorized projects (1996/1999 Common Features, the Joint Federal Project (JFP), and the Folsom Dam Raise) are in place and functional.
- Describe the residual flood risk -- the remaining flood risk once a project is built -- associated with each alternative in the Final Array.
- Summarize the results of the net benefit and benefit-to-cost analyses for each alternative in the Final Array.
- Identify the National Economic Development (NED) Plan, which is the alternative that reasonably maximizes net benefits.

1.2 BACKGROUND

In February of 1986, major storms in Northern California caused record flows in the American River Watershed. Outflows from Folsom Reservoir, together with high flows in the Sacramento River, caused water levels to rise above the safety margin on levees protecting Sacramento. The effects of the 1986 storms raised concerns over the adequacy of the existing flood control system. These concerns led to a series of study authorizations and investigations into the need for additional flood protection for the Sacramento area. Some of the key milestones and reports in this process, spanning more than 20 years, are listed in Table 1.

Table 1: Timeline of Key Events and Reports

YEAR	KEY EVENT	REPORT
1986	Severe storms in Northern California raise concerns over level of flood protection in Sacramento area	
1988	Continuing Appropriations Act funds American River Watershed Investigation	
1989	The Sacramento Area Flood Control Agency (SAFCA) is established	
1991		American River Watershed (ARW) Investigation Feasibility Report and Environmental Impact Statement/Report (EIS/EIR) recommends levee improvements in portions of Sacramento and detention dam at Auburn
1993	Defense Appropriations Act (DAA) authorized	

	a portion of the Natomas Basin levee improvements proposed in 1991 Feasibility Report and directs USACE to conduct new FRM study	
1996	Congress defers decision on Auburn Dam, but authorizes more levee improvements common to all candidate plans outlined in SIR; these "common features" authorized in WRDA 1996; Auburn Dam rejected in late 1996/early 1997	ARW, Supplemental Information Report (SIR) and EIS/R identifies 3 plans to reduce flood risk: Folsom Dam Modifications, Stepped Release Plan, Auburn Dam Plan (NED Plan)
1997	Severe storms in the region once again highlight flood risk in the Sacramento area	
1998		SAFCA releases Folsom Dam Modifications Report – New Outlets Plan; report presents alternatives to lower spillway under 1996 SIR's Folsom Dam Modifications Plan
1999	1999 WRDA authorizes 1996 SIR's Folsom Modifications Plan (as modified by SAFCA) and directs USACE to conduct additional FRM studies	
2001		Common Features (CF) Limited Reevaluation Report (LRR) identifies improvements to reduce flood risk to Lower American River area; Section 366 of WRDA 1999 further modifies 1996 WRDA in regard to CF – specific direction is given related to levee modifications that would allow increase outflows from Folsom Dam to a sustained 160,000 cfs without high likelihood of levee failure along Lower American River
2002		ARW Long-Term Study and EIS/R recommend raising Folsom Dam by 7
2003	Energy and Water Development Appropriations Act (2004) authorizes 7-foot dam raise at Folsom Dam	Folsom Dam Modification Project LRR and Environmental Assessment (EA)/EIS reconcile conflicts between authorized Folsom Modification Project and 2002 Long-Term Study Feasibility Report recommendations
2005	Energy and Water Development Appropriations Act (2006) directs the USACE and Bureau of Reclamation to collaborate on FRM planning (USACE mission) and dam safety (Bureau mission) efforts related to Folsom Dam	
2005	In the aftermath of 2005 Gulf Coast hurricane (Katrina), the limitations of the FRM system in the Sacramento area and the need to improve this system gain increased public attention	
2007		Folsom Modification and Dam Raise Project, Post-Authorization Change (PAC) Report describes recommended changes to 2 authorized projects (Folsom Modification and Folsom Dam Raise Projects), and evaluates Joint Federal Project (JFP), which addresses both FRM and dam safety objectives

2008	Start of American River Common Features (ARCF) GRR	Folsom Modification and Dam Raise Projects, Economic Reevaluation Report (ERR) describes potential FRM alternatives at Folsom Dam; analysis revised 2007 PAC Report by updating economic inventory, economic models, and evaluating Regional Economic Development (RED) and Other Social Effects (OSE) accounts
2009	F3 without-project condition milestone conference is held in Sacramento, CA; following conference, decision made to evaluate potential FRM alternatives in Natomas Basin on accelerated schedule and separately from other basins	
2010	Continuation of ARCF GRR efforts from 2009	Natomas Basin PAC and Interim GRR approved and sent to Congress; recommends improving existing levees surrounding the basin, but defers levee raise analysis to full GRR

1.3 STUDY AREA AND BASINS

The American River Watershed drains about 2,100 square miles northeast of Sacramento and includes portions of Placer, El Dorado, and Sacramento counties. Runoff from this basin flows through Folsom Reservoir and passes through Sacramento within a system of levees. Folsom Dam and Reservoir, located on the American River about 25 miles east of the city of Sacramento, form a multi-purpose water project. The project was constructed by the U.S. Army Corps of Engineers (USACE) and is operated by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) as part of the Central Valley Project (CVP). The reservoir has a normal full-pool storage capacity of 975,000 acre-feet with a minimum seasonally designated flood control storage space of 400,000 acre-feet.

Within the watershed, the study area includes three distinct areas:

- Natomas Basin, which lies to the north of downtown Sacramento
- American River North area (hereafter referred to as ARN), which lies east of the Natomas Basin and north of the American River
- American River South area (hereafter referred to as ARS), which lies east of the Sacramento River and south of the American River.

Each area is at risk of flooding from multiple sources. Table 2 below lists these sources; Figure 1 below displays these sources on a map of the study area.

Table 2: Sources of Flooding by Basin

BASIN	SOURCES OF FLOODING
Natomas (NAT)	Sacramento River
	Natomas Cross Canal (NCC)
	Natomas East Main Drainage Canal (NEMDC)
	Pleasant Grove Creek Canal (PGCC)
	American River
American River North (ARN)	American River
	Natomas East Main Drainage Canal (NEMDC)
	Pleasant Grove Creek Canal (PGCC)
	Dry Creek
	Robla Creek
	Magpie Creek
	Arden Creek
American River South (ARS)	American River
	Sacramento River

Figure 1: Study Area, Basins, and Major Sources of Flooding

1.4 ECONOMIC ANALYSIS IN PRIOR REPORTS

Prior reports associated with the American River Watershed Study are listed in Figure 2 below. These reports serve as an historic timeline for which to better understand the basis for the economic analysis contained in this GRR. For each study listed, a brief description is given of the conclusions of the economic analysis; additionally, any parts (e.g., assumptions, data, models, etc.) of one analysis that were carried forward to subsequent analyses are also described.

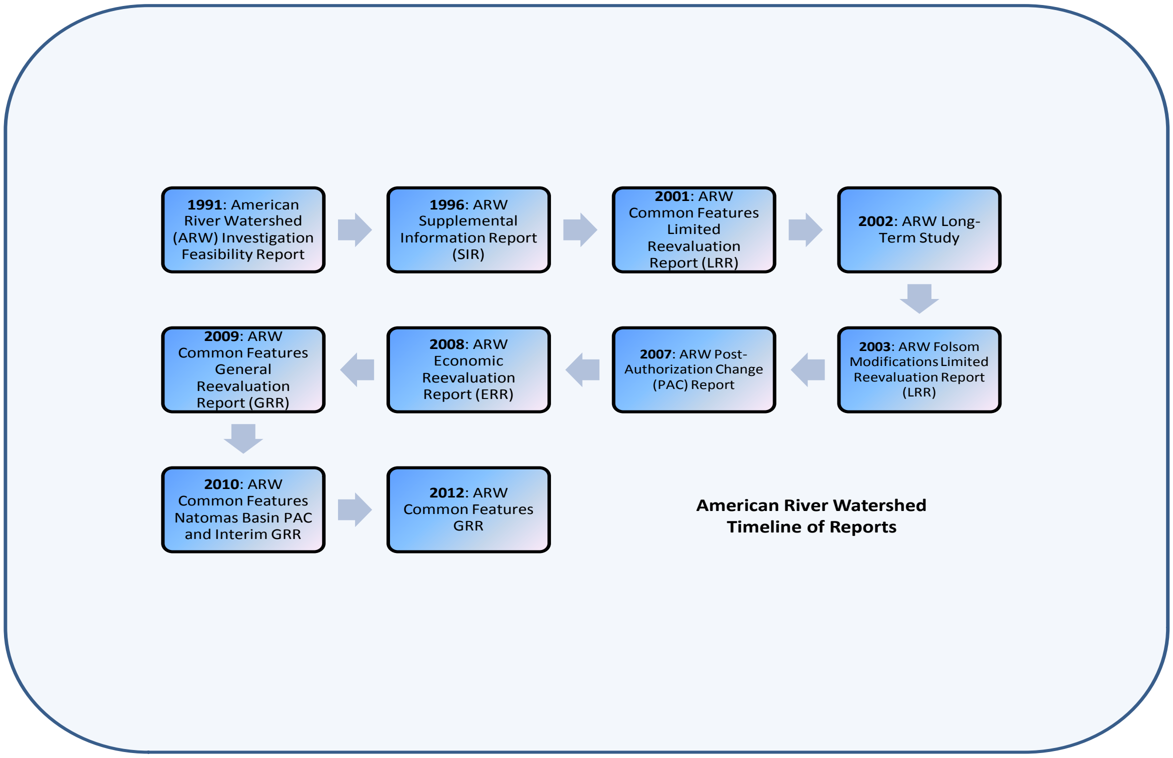


Figure 2: Prior American River Watershed Study Reports

- *American River Watershed Investigation Feasibility Report, 1991*

  This report recommended a detention dam at Auburn, which ultimately was not authorized by Congress. It was estimated that a detention dam at Auburn would have reduced Sacramento's flood risk to about a 1 in 200 chance in any given year based on non-risk analysis methodologies.[1] Following this report, two of many incremental projects, including the Sacramento Area Flood Control Agency (SAFCA) North Area Levee Improvement Project (NLIP) in Natomas and the reoperation of Folsom Dam from 400,000 acre-feet fixed flood control space to a 400,000/670,000 acre-feet variable flood control space, were adopted to help reduce flood risk to Sacramento.

  For the 1991 economic analysis, long-duration non-residential structural depth-percent damage curves were developed; these curves were used to modify the Federal Emergency Management Agency (FEMA) curves for the 2008 ERR, and were then applied to those areas prone to deep and long-duration flooding. These adjusted FEMA curves were carried forward to the 2010 Natomas PAC and Interim GRR, as well as to this current GRR effort. Much of the other engineering and economic data developed for the 1991 Feasibility Report has been replaced by more current data.

[1] Risk analysis methodologies were not implemented at the USACE until after the completion of the 1991 Feasibility Report.

- *American River Watershed Supplemental Information Report, 1996*

  This report was the first American River Watershed report to use a risk analysis methodology to determine economic benefits. The report identified three final alternatives: the Stepped Release, the Folsom Modifications, and the Detention Dam plans. While the Detention Dam was determined to be the National Economic Development (NED) Plan, it was not recommended in the Chief's report and therefore not authorized. Instead, a less controversial Common Features alternative was authorized. A benefit of this alternative, which included features that were part of all three final alternatives, was that it would not preclude future selection of any of the three final alternatives.

- *American River Watershed Common Features LRR, 2001*

  The 2001 Common Features LRR estimated that, with levee improvements in place, outflows from Folsom Dam could be increased to 160,000 cubic feet per second (cfs) for a sustained period of time without introducing a high probability of levee failure along the American River. Annual exceedance probability (AEP) on the Lower American River was estimated to be 0.0099, or about a 1 in 100 chance. Annual flood risk management (FRM) benefits of approximately $19 million and annual FRM costs of $10 million resulted in a benefit-to-cost ratio (BCR) of 1.9.

  The 2001 LRR split Common Features into the Lower American River levee improvements and the Natomas Basin area. The Natomas Basin area required significant reformulation and development of a GRR, which subsequently was included as part of the 2008 Common Features GRR, the 2010 Natomas Basin Post-Authorization Change Interim & General Reevaluation Report, and finally this current effort for the Common Features GRR.

  Additionally, levee performance assumptions documented in the 2001 LRR served as the basis for subsequent reports, including the 2007 PAC and the 2008 ERR; however, differences in the economics, hydrology, hydraulics, and geotechnical inputs preclude a direct comparison of damages, benefits, and project performance between the 2001 LRR and the 2007 PAC, 2008 ERR, and this current GRR.

- *American River Watershed Long-Term Study, 2002*

  The purpose of the Long-Term Study was to address the residual flood risk remaining once the Folsom Modifications project was completed. The Long-Term Study evaluated an array of FRM alternatives that included dam raises ranging from 3.5 to 12 feet. The study determined that a 7-foot raise of Folsom Dam that provided both additional FRM and dam safety[2] would be the most optimal economic solution, exclusive of the Detention Dam alternative.

  Congress, through the Energy and Water Development Appropriations Act for fiscal year 2004, authorized several project features which were recommended by the Long-Term Study: raising Folsom Dam by 7 feet, modifying the L.L. Anderson Dam spillway, constructing a permanent bridge downstream from Folsom Dam, and modifying the emergency release operations to permit surcharge. First costs for this project were estimated at around $249 million, with $128

[2] Dam safety in this instance refers to enabling the dam facility to pass one-hundred percent of the probable maximum flood, or PMF.

million allocated to FRM. Annual FRM benefits of $19 million and annual FRM costs of $10 million provided a BCR of 1.9 to 1. At the time, this project was estimated to reduce the risk of flooding to a 0.0057 annual exceedance probability (AEP)[3], or about a 1 in 175 chance.

Two project components of the 2002 Long-Term Study, the 3.5-foot dam raise and the 7.0-foot dam raise, were also evaluated in the 2007 PAC and 2008 ERR. The 2007 PAC recommended an alternative that included a 3.5-foot dam raise component, and the 2008 ERR confirmed this recommendation as the most optimal amongst the alternatives evaluated. Section 1.5 describes in greater detail the projects previously authorized and either have been or will be constructed.

- *American River Watershed Folsom Modifications LRR, 2003*

The 2003 LRR reconciled conflicts between the authorized Folsom Modifications Project elements and recommendations in the 2002 Long-Term Study. As directed by Congress in WRDA 1999, the plan identified in the 2002 Long-Term Study included raising Folsom Dam, modifying downstream levee improvements, and implementing other elements necessary to meet current Federal dam safety standards. These authorized features, which make up the Folsom Dam Raise Project, carry design implications for the previously authorized Folsom Modifications Project.

The 2003 LRR refined the elements related to increasing release capacity to be consistent with gate modifications in the 2002 Long-Term Study. These changes included constructing two new upper-tier outlets, enlarging the four existing upper-tier outlets to 9 feet 4 inches by 14 feet and the four existing lower-tier outlets to 9 feet 4 inches by 12 feet, and modifying the existing main spillway stilling basin.

In addition, for the surcharge storage aspect of the project, the three emergency spillway tainter gates would be replaced with larger gates, as authorized, but the design would permit expansion of these gates in the future should the Folsom Dam Raise Project be authorized (which it has been) and implemented.

The Folsom Modifications revised economics report (November 2003) identified the recommended project as new and enlarged existing outlets capable of releases of 115,000 cfs and improvements allowing for the use of surcharge storage up to Elevation 474 feet. First costs for this project were estimated at around $214 million with annual benefits of $32 million and annual costs of $16 million providing a benefit-to-cost ratio of 2.0 to 1. At the time this project was estimated to reduce the risk of flooding to a 0.0071 annual exceedance probability, or about a 1 in 140 chance.

During the construction proposal process, the cost estimates exceeded the fully funded authorized costs (Section 902 limit). Consequently, dam operations and performance and alternate structural methods to achieve the risk reduction provided by the outlet modifications were reexamined. Subsequent studies also found that modification of the two outboard lower-tier outlets was infeasible, and offered only a marginal increase in performance.

[3] In the Long-Term Study, advanced forecast releases were evaluated as part of the alternatives. With advance releases factored in, project performance (as measured by AEP -- the probability flooding will occur in any given year considering the full range of possible annual floods), improved to 0.0047. Advance releases were not considered in the 2007 PAC, 2008 ERR, or in this current GRR effort.

The alternatives evaluated in the 2008 ERR included construction measures (eight of the total 10 outlets described) included in the 2003 LRR.

- *American River Watershed PAC Report, 2007*

  The purpose of the PAC report was to document changes to two authorized projects: the Folsom Modifications Project and the Folsom Dam Raise Project. Both projects share an objective of improving flood risk management on the Lower American River, primarily through structural modifications to the existing Folsom Dam.

  In the PAC report, project elements from both the Folsom Modifications and the Long-Term Study were considered not only for the purpose of flood risk management but also for dam safety. During the design refinements for Folsom Modifications, it was believed that due to significant increases in the cost estimates that the authorized project may not be optimal or even economically feasible. During this preliminary analysis, it appeared that adding operational gates to the proposed Bureau of Reclamation dam safety auxiliary spillway may provide a more efficient way to meet two project purposes.

  The Folsom Dam Joint Federal Project was intended to meet the goals of the Corps of Engineers as well as the Bureau of Reclamation; its analysis became one of the main focuses of the PAC. As mentioned, the PAC economic analysis included elements of three authorizations, the Folsom Modifications, the Dam Raise, and Reclamation's dam safety project. The combined project's objectives in terms of economic outputs and project performance were: (1) Reduce flood damages as effectively and efficiently as possible within a limited schedule and without complete reformulation, (2) effectively pass the 200-year design flow event without levee failure (based on design non-risk-based criteria), and (3) pass the PMF without placing the dam structure in danger of failure.

  The PAC and follow-on ERR evaluated a final array of four action alternatives. Alternative C, as described below, was the recommended plan from both studies. Alternative C included six submerged tainter gate auxiliary spillway, 3.5-foot dam raise, and three emergency spillway gate replacements. The recommended plan is summarized in Table 3 below.

Table 3: Benefits, Costs, and Project Performance of 2007 PAC Recommended Plan

SUMMARY CRITERIA	RECOMMENDED PLAN
Performance:	
Passes PMF	Yes
Annual exceedance probability (AEP)	0.0054
Design flood event (non-risk-based criteria)	1 in 240
Costs and benefits:	
First costs (FRM only)	$788 million
Annual costs (FRM only)	$40 million
Annual benefits (FRM only)	$107.1 million
Net benefits (FRM only)	$67.1 million
Benefit-to-cost ratio (BCR)	2.7
Residual damages	$91.1 million
Percent damage reduction	54%

Notes: 1) Values in October 2006 prices 2) FRM = flood risk management

- *American River Watershed ERR, 2008*

  The main purpose of the ERR was to affirm that the recommended plan from the PAC was economically feasible and was the most efficient among the array of alternatives considered.

  The focus of the ERR was to update the economics and the HEC-FDA modeling (including the hydrologic and hydraulic data) from previous analyses to develop a more accurate, comprehensive, and system-wide characterization of flood risk for the study area. This update included evaluation of the National Economic Development (NED), Regional Economic Development (RED), and Other Social Effects (OSE) accounts, development of a new structure inventory, re-estimation of structure and content values using data collected through extensive fieldwork and an expert-opinion elicitation panel, and a re-computation of damages and benefits using new, locality-specific non-residential content depth-percent damage curves, seven event-based floodplains (instead of only one as in previous analyses), and more defined consequence areas.

  The ERR estimated that total without-project expected annual damages (EAD) was approximately $277 million, not including the Natomas Basin. The with-project residual damages and benefits were estimated for the same four action alternatives that were evaluated in the 2007 PAC. The results of this alternatives analysis are presented below in Table 4.

Table 4: Net Benefit and Benefit-to-Cost Analyses from ERR

ITEM	ALT A	ALT B	ALT C	ALT D
Total Project First Costs	650.4	918.1	1,042.1	1,555.6
Annual Benefits (2018-2067)	98.1	116.3	143.8	172.2
Annual Benefits During Construction (2012-2017)	32.6	26.9	29.9	26.9
Total Annual Flood Risk Management Benefits	130.7	143.2	173.7	199.1
Annual Costs	46.6	62.3	68.0	98.2
Savings in Avoided Dam Safety Costs	0	(15.3)	(15.3)	(15.3)
Net Flood Risk Management Annual Costs	46.6	47.0	52.7	82.9
Net Benefits	84.1	96.2	121.0	116.2
Benefit-to-Cost Ratio	2.8	3.0	3.3	2.4

Notes: 1) Values in millions, October 2007 prices, 50-year period of analysis, 4.875% discount rate 2) Alternative A includes eight main dam outlets and fuse plug spillway; Alternative B includes a six submerged tainter gate auxiliary spillway; Alternative C includes a six submerged tainter gate auxiliary spillway, a 3.5-foot dam raise, and three emergency spillway gate replacements; Alternative D includes a six submerged tainter gate auxiliary spillway, a 7-foot dam raise, and eight emergency and service spillway gate replacements 3) Alternatives B, C, and D would eliminate the need for construction of the dam safety only fuse plug as part of the future without-project condition; the $15.3 million reduction in dam safety costs was taken as a savings from the net flood risk management annual costs.

The ERR confirmed the 2007 PAC recommendation of Alternative C – which included a six submerged tainter gate auxiliary spillway, a 3.5-foot dam raise, and three emergency spillway gate replacements. Total annual FRM benefits of Alternative C were estimated at $173.7 million, of which $29.9 million was attributed to benefits during construction. Residual expected annual damages of Alternative C were estimated to be approximately $133 million (American River North and South Basins).

- *American River Watershed Common Features F3 GRR, 2009*

Key data used in the ERR were carried forward to the 2009 GRR, including the extensive structure inventory and the non-residential content valuations/depth-percent damage curves. Other data were updated for the GRR, including the number of sources of flooding (American River, Sacramento River, Natomas Cross Canal, Pleasant Grove Creek Canal, Natomas East Main Drainage Canal) used to estimate flood risk, the consequence areas considered (Natomas was included where it was not in the ERR), the levee fragility curves (geotechnical), the Folsom Dam routings (hydrology), and the rating curves/floodplains (hydraulics).

In the economic analysis for the 2009 GRR, EAD for the future without-project condition (Authorized Common Features + Joint Federal Project + Folsom Dam Raise) for the ARN, ARS, and Natomas Basins were estimated to be approximately $27.7 million, $132.5 million, and $2.4 billion, respectively. Project performance in terms of annual exceedance probability (AEP) for each area was estimated to be approximately 0.007 (ARN), 0.008 (ARS), and 0.390 (Natomas). In March of 2009, an F3 (without-project condition) milestone conference was held at the Sacramento District office. Based on the outcomes of this conference, the path forward was determined to be to study the Natomas Basin area separately from the rest of the study area (ARS and ARN) via a Natomas Basin Post-Authorization Change & Interim GRR.

- *American River Watershed Natomas Basin PAC Interim GRR, 2010*

  Soon after the March 2009 F3 milestone conference, the American River Common Features project delivery team (PDT) was charged with studying the Natomas Basin as a separate entity from the rest of the Common Features GRR study area, recommending an alternative(s) for the Natomas Basin via a Post-Authorization Change & Interim GRR, and completing this report within a highly accelerated schedule. This report was in fact completed in December 2010, approximately 20 months following the initial charge, and subsequently was approved by the Civil Works Review Board, signed by the Chief of Engineers, sent to the Office of Management and Budget (OMB), and submitted to Congress. Congress authorized the project in 2014.

  The Natomas Basin PAC & Interim GRR focused on improving the existing levees (either in place or via adjacent levees) surrounding the Basin along all five waterways, including the Sacramento River, American River, Natomas East Main Drainage Canal (NEMDC), Pleasant Grove Creek Canal (PGCC), and the Natomas Cross Canal (NCC); analysis of levee raises were deferred to the GRR. However, the Natomas Basin has since been removed from the GRR alternatives.

  The Natomas PAC Interim GRR recommended improving the levees along all waterways surrounding the Natomas Basin. It was estimated that the Recommended Plan would reduce without-project EAD by about 96%, or from approximately $462 million in EAD to approximately $19 million in EAD, producing average annual benefits of approximately $443 million. The project cost was estimated to be approximately $67.8 million (average annual). Net benefits and the BCR were estimated to be approximately $375.2 million (average annual) and 6.5, respectively. Once completed, the improvements were expected to reduce the probability of flooding in any given year from about a 1 in 5 chance to about a 1 in 67 chance.

1.5 SUMMARY OF PREVIOUSLY-AUTHORIZED FLOOD RISK MANAGEMENT IMPROVEMENTS ALREADY CONSTRUCTED OR CURRENTLY UNDER CONSTRUCTION

Three major American River Watershed projects have been previously authorized by Congress as outlined above. These include the 1996/1999 Authorized Common Features Project, the Joint Federal Project (JFP), and the 3.5-foot Folsom Dam Raise Project. Figure 3 below lays out these improvements, starting with no improvements in place and leading up to the 3.5 foot Folsom Dam Raise (rectangles); the large oval represents the alternatives that were considered for this current GRR effort.

It is important to point out that while these projects have been authorized and/or implemented in an incremental nature, these improvements are interdependent and rely on one another to fully maximize risk reduction from a system-wide perspective.

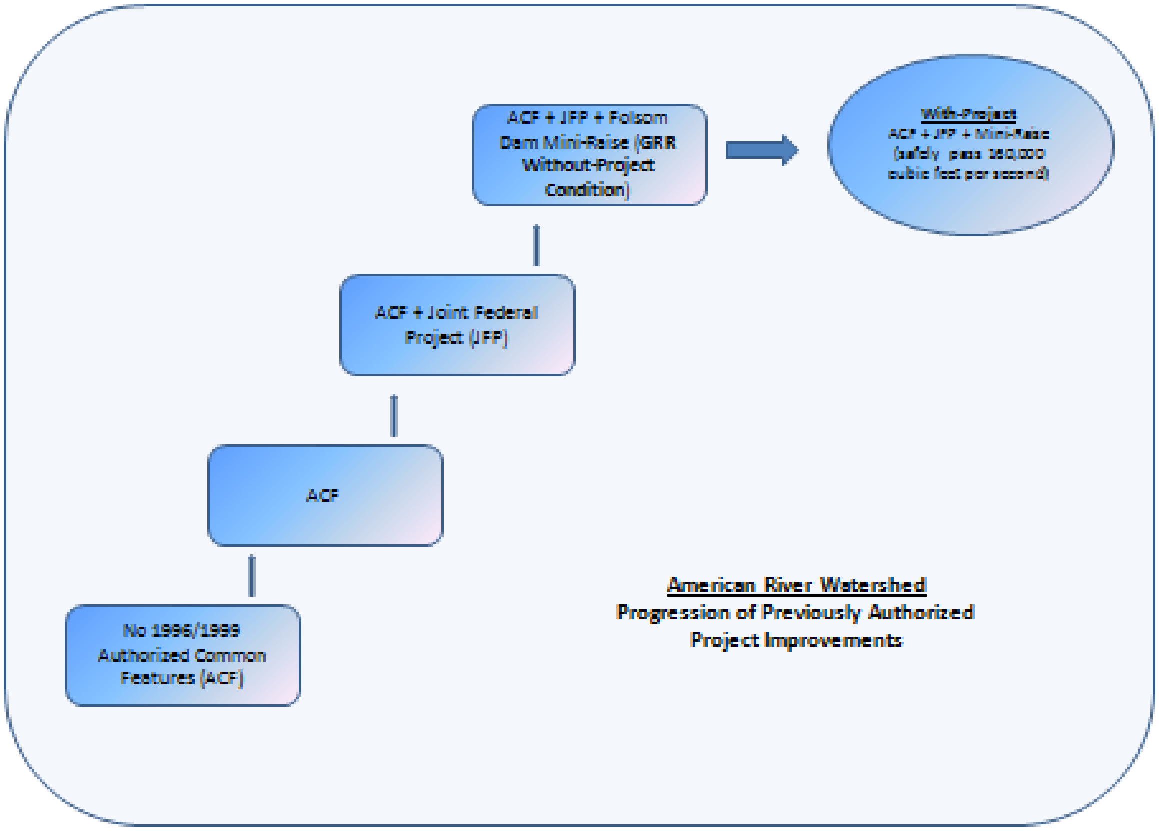


Figure 3: FRM Improvements Authorized Under the American River Watershed Study

1.6 FUTURE WITHOUT-PROJECT CONDITION

For this current GRR effort, the future without-project condition assumes that the previously authorized 1996/1999 Common Features improvements, JFP, and Folsom Dam Raise are in place and functional by the year 2020. This without-project condition is represented by the top rectangle in Figure 3. System-wide risk reduction was estimated by comparing the economic outputs of each alternative evaluated (represented by the large oval in Figure 3) against the future without-project condition.

1.7 ORGANIZATION & CONTENT

This report is organized around four main chapters. The contents of each chapter are summarized in Figure 4 below.

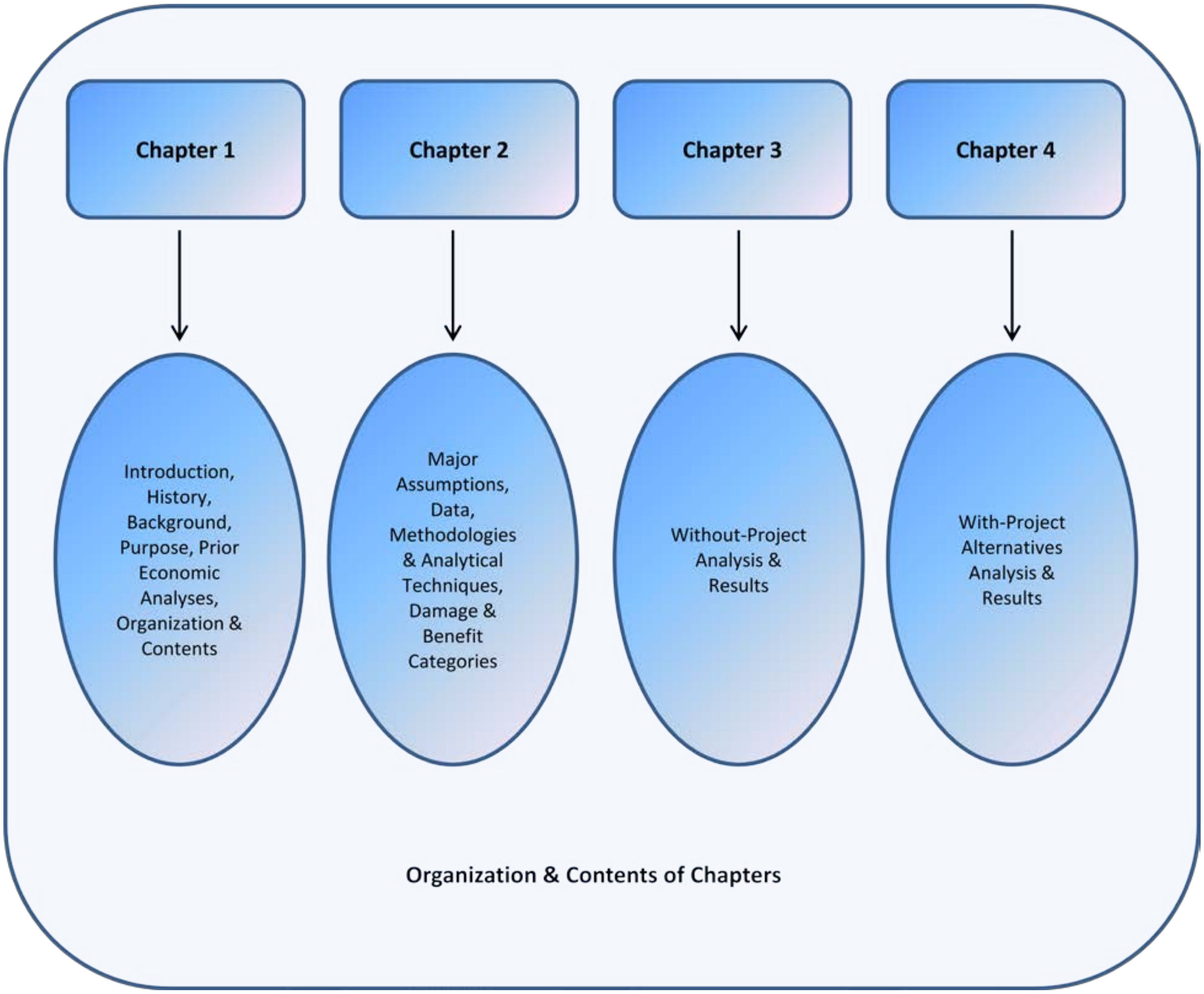


Figure 4: Content of Chapters

CHAPTER 2
FRAMEWORK OF ECONOMIC ANALYSIS

2.1 CONSISTENCY WITH CURRENT REGULATIONS & POLICIES

The analysis presented in this document was performed using the most up-to-date guidance and is consistent with current regulations and policies. Various references were used to guide the economic analysis, including:

- The *Planning Guidance Notebook* (ER 1105-2-100, April 2000, with emphasis on Appendix D, Economic and Social Considerations, Amendment No. 1, June 2004) serves as the primary source for evaluation methods of flood risk management (FRM) studies
- EM 1110-2-1619, *Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies* (August 1996)
- ER 1105-2-101, *Planning Risk-Based Analysis for Flood Damage Reduction Studies* (Revised January 2006)
- Economic Guidance Memorandum (EGM) 01-03, *Generic Depth-Damage Relationships* (2000)
- Economic Guidance Memorandum (EGM) 04-01, *Generic Depth-Damage Relationships for Residential Structures with Basements* (2003)
- Economic Guidance Memorandum (EGM) 09-04, *Generic Depth-Damage Relationships for Vehicles* (2009)

2.2 PRICE LEVEL, PERIOD OF ANALYSIS, AND DISCOUNT RATE

Values listed in this document are based on an October 2015 price level. Annualized benefits and costs were computed using a 50-year period of analysis and a current federal discount rate of 3.125%. Unless otherwise noted, annualized values are presented in thousands of dollars.

2.3 MAIN ASSUMPTIONS

Several main assumptions were relied upon in order to reasonably and efficiently study the problem (i.e., flooding) and its solutions (i.e., flood risk management alternatives), and then ultimately reach a conclusion using the limited resources available:

- The without-project condition assumes that the 1996/1999 Authorized Common Features improvements, Joint Federal Project, and Folsom Dam Raise are in place and functional; this assumption is reflected in the hydrologic (transform flow), hydraulic (floodplains and rating curves) and geotechnical (levee fragility curves) engineering data used in the economic analysis
- The future without-project operations at Folsom Dam assume a target release of 160,000 cubic feet per second (cfs) for the 200-year event; this assumption is reflected in the hydrologic transform flow curves used for the without-project condition
- The with-project operations at Folsom Dam assume a target release of 160,000 cfs for the 200-year event, also known as the 0.5% annual chance exceedance (ACE) event, and which has a 1 in 200 chance of occurrence (these terms will be used interchangeably throughout this document); this assumption is reflected in the hydrologic transform flow curve used for the with-project condition

- All areas except the Natomas Basin assume build-out and no future development
- For the Natomas Basin, additional development was accounted for but only to describe the residual risk associated with a project; no benefits were claimed for future development. (A discussion on residual risk in the Natomas Basin can be found in the Economic Appendix for the Natomas Post-Authorization Change & Interim GRR.)
- That the hydrologic, hydraulic, and geotechnical conditions within the study area would remain the same between the without-project and the most likely future without-project conditions. Most likely future (without-project) hydrologic, hydraulics, and geotechnical engineering data for input into the economic modeling were assumed to be the same as the base without-project condition
- That damages resulting from out flanking from the non-leveed portions of the American River upstream of existing levees would not be reduced even with a project in place; this assumption was factored into the estimation of benefits for the ARS and ARN basins.

2.4 METHODOLOGIES, TECHNIQUES, & ANALYTICAL TOOLS

Various methodologies, analytical techniques, and tools were used to perform the economic analysis. The majority of those used for this analysis is standard to many Corps of Engineers studies and are described in the appropriate sections throughout this document. Several of the main ones used in this analysis are described below.

2.4.1 Economic Analytical Tool: HEC-FDA Software

The main analytical tool used to perform the economic analysis was the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software, version 1.2.5a. This program stores the engineering data (hydrologic, hydraulic, and geotechnical) and the economic data (structure/content inventory and depth-percent damage curves), and is used to model the flooding problem and potential alternative solutions in the study area.

By relating the economic inventory data to the floodplain data, the HEC-FDA software computes economic stage-damage curves. Through integration of the main engineering relationships (exceedance probability-discharge curves, rating curves, and geotechnical levee fragility curves) and the main economic relationship (stage-damage curves), the HEC-FDA software computes project performance statistics and expected annual damages/benefits.

The results of the economic modeling are then used as input into the net benefit and benefit-to-cost analyses and may also aid in plan formulation, all of which are performed external to the HEC-FDA software.

2.4.2 Floodplain Data in HEC-FDA Using FLO-2D Model Output

The SPK Hydraulic Design Section developed floodplains using the FLO-2D model, which produces interior water surface elevations by grid cell. The model generates suites of FLO-2D floodplains {0.5 (1/2), 0.1 (1/10), 0.04 (1/25), 0.02 (1/50), 0.01 (1/100), 0.005 (1/200), and 0.002 (1/500) annual chance exceedance events}; suites were developed for each index point. (See Section 2.6 for discussion of representative index points).

Importing the FLO-2D data into the HEC-FDA models required file formatting. The FLO-2D files were formatted so that the HEC-FDA program would import them as a HEC-RAS water surface profile (WSP) output file. Instead of using river station numbers like in a typical HEC-RAS WSP, assignment of water surface elevations by frequency event were completed using grid cell numbers (output of FLO-2D); the grid cell assignments represent actual floodplain water surface elevations by frequency event rather than in-channel water surface elevations.

2.4.3 Computing Stage-Damage Curves in HEC-FDA

The formatted WSPs included every grid cell that contained a structure and the water surface elevations in each grid cell for each frequency event. The suite of floodplains along with the imported structure inventory was used in HEC-FDA to compute stage-damage curves.

Once the formatted floodplain data were imported into HEC-FDA, a row was inserted at the top of the WSP which included the in-channel stages associated with the index point (for a particular impact area). This step allowed for the linkage between the two-dimensional floodplain data and the in-channel stages. Importing formatted floodplain data and assigning water surface elevations to grid cells eliminated the need for creating interior-exterior relationships, which is another way to link exterior (river) stages to interior (floodplain) stages within HEC-FDA.

2.4.4 Multiple-Source Flooding into Single Consequence Area

Multiple sources of flooding within a single consequence area complicate the economic risk analysis in terms of estimating the chance of flooding and the consequences of flooding in that consequence area. Additional analytical complexity is introduced if one considers that the probability of flooding along a particular flooding source also varies (i.e., not only is the probability of flooding between various water sources not uniform but the probability of flooding along a specific water source is also not uniform), and that the same area is flooded from levee breaches at different locations but at varying magnitudes (i.e., different floodplains) depending on the location of the breach.

The risk analysis was performed using eight representative index points, with each point tied to a specific source of flooding within the study area. The same index points were used for both the without-project and with-project analysis. Section 2.6 below describes in more detail the index points used and their locations.

2.5 ECONOMIC IMPACT AREAS (EIA)

Economic impact areas (EIA) were delineated in order to facilitate the economic risk analysis. These areas enable the direct computation and reporting of consequences that result from flooding from a specific source under both the without-project and with-project conditions. Three main EIAs within the study area were identified:

- American River North Basin (ARN)
- American River South Basin (ARS)
- Natomas Basin (NAT)

During the 2007 PAC/2008 ERR, sub-EIAs within two of the main EIAs (ARN and ARS) were identified in order to more precisely (by neighborhood within a basin) analyze residual risk. These impact areas are presented below but were not carried forward to this analysis. Figures 5 and 6 display the three main EIAs (NAT, ARN, ARS) and the sub-EIAs within the ARN and ARS Basins. It should also be noted that the boundaries of the EIAs presented in Figure 6 do not correspond to any particular ACE event flood plain used in the current analysis.

ARS:

- ARS 1 Pocket/Greenhaven
- ARS 2 Fruitridge/Meadowview
- ARS 3 Land Park
- ARS 4 Downtown Sacramento
- ARS 5 East Sacramento
- ARS 6 Rancho Cordova
- ARS 7 Gold River
- ARS 8 South I-50/Florin/Watt
- ARS 9 Florin South
- ARS 10 Mather North
- ARS 11 Rosemont
- ARS 17 South of Morrison Creek

ARN:

- ARN 13 American River Drive
- ARN 14 Arden/Expo
- ARN 15 North Sacramento
- ARN 16 Dry Creek

The smaller sub-economic impact areas (neighborhoods) were not used for the current analysis but instead aggregated into two larger impact areas (ARS and ARN Basins); this aggregation is unlikely to affect the accuracy of the results in terms of damages, benefits, or plan selection. Aggregating the sub-impact areas allowed for a more streamlined approach to the analysis that required fewer models, which then translated into fewer model runs, fewer sets of output results, less documentation, and ultimately time savings.

It should also be noted that there is a trade-off in terms of detail/precision by aggregating the sub-EIAs into one FDA model/inventory/impact area. Since models are run by basin and results are also reported by basin rather than sub-impact area, seeing how a neighborhood within the basin is affected by a project is not as apparent. However, since each structure is still identified by sub-impact area (e.g., 1-17) within the aggregated inventory, this information is not lost and could be ascertained if necessary.

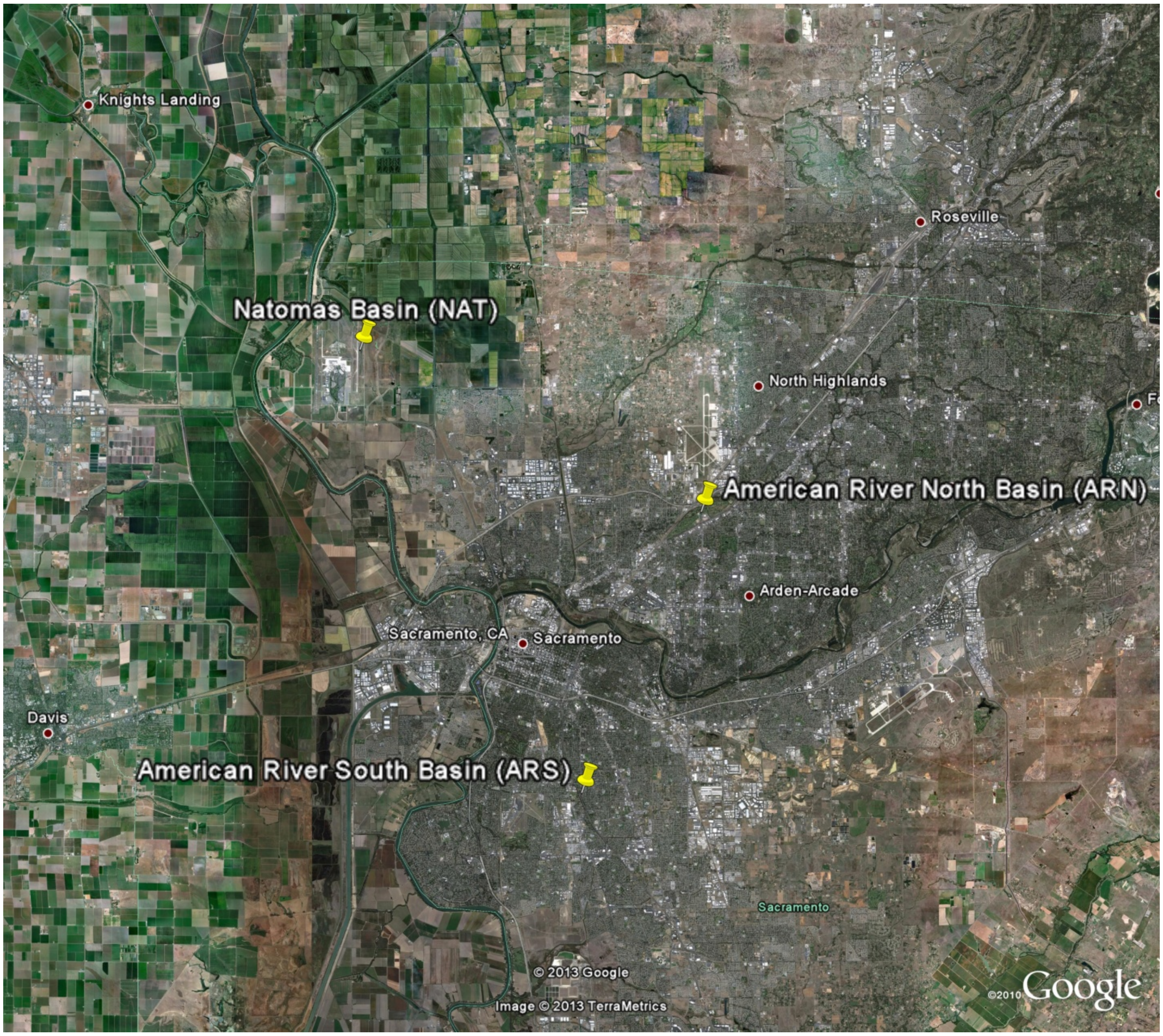


Figure 5: Main Economic Impact Areas (Basins)

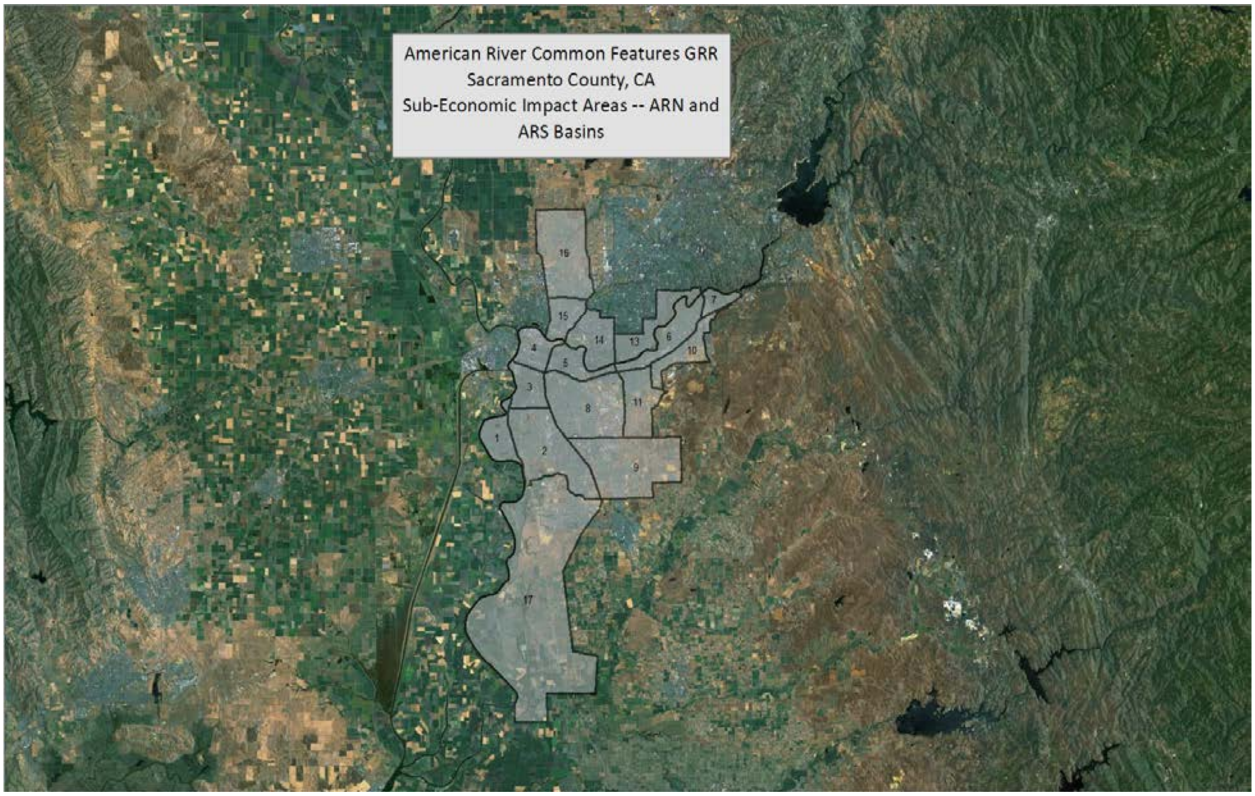


Figure 6: Sub-EIAs in the ARS and ARN Basins

2.6 HYDRAULIC REACHES & REPRESENTATIVE INDEX POINTS

Chapter 1 (Section 1.3) explained that each basin/EIA may be at risk of flooding from multiple sources. For example, the ARS Basin could be flooded from either the American or Sacramento Rivers. Additionally, along each source of flooding, the condition of the levee could vary from one location (hydraulic reach) to the next, with the probability of flooding from a particular reach varying correspondingly.

In terms of economic analysis, levee reaches are used to focus-in on those areas deemed most pertinent for developing engineering data, which feed into the economic modeling. Data are generated at representative index points within each reach and are used to estimate project performance statistics under both without-project and with-project conditions. The engineering data is also used in conjunction with economic data to estimate expected damages and benefits. Both sets of results are then used together to describe the flood risk in the study area.

Twenty-five hydraulic reaches were originally identified based on extensive geotechnical analyses of the levee conditions along each source of flooding within the study area. From these 25 reaches, the project delivery team (PDT) selected five of them, each containing one index point, for which to generate engineering data for use in the economic modeling and the associated without-project damage and with-project benefit analyses. The PDT also selected three additional index points -- two located on the right and left banks of the American River and one located on the NEMDC/PGCC (also known as the Sankey Gap) at locations where there are no levees. These index points were not part of the original 25, but were included in order to aid in a more accurate description of residual flood risk in the study area. The representative index points used in economic analysis were selected based on preliminary estimates of the chance of flooding and consequences of flooding using flood plain extents and depths, levee fragility (geotechnical fragility curves), and estimates of ACE event damages. The index points, by basin, are shown in Figure 7 and listed below.

ARS:

- ARS A, American River, RM 9.0, left bank
- Flanking location on American River, RM 14.5, left bank
- ARS F, Sacramento River, RM 50.25, left bank

ARN:

- ARN A, American River, RM 7.82, right bank
- Flanking location on American River, RM 13.21, right bank
- ARN E, Arcade Creek, RM .88, right bank

NAT:

- NAT D, Natomas Cross Canal, RM 4.3, left bank
- Sankey Gap on the NEMDC/PGCC

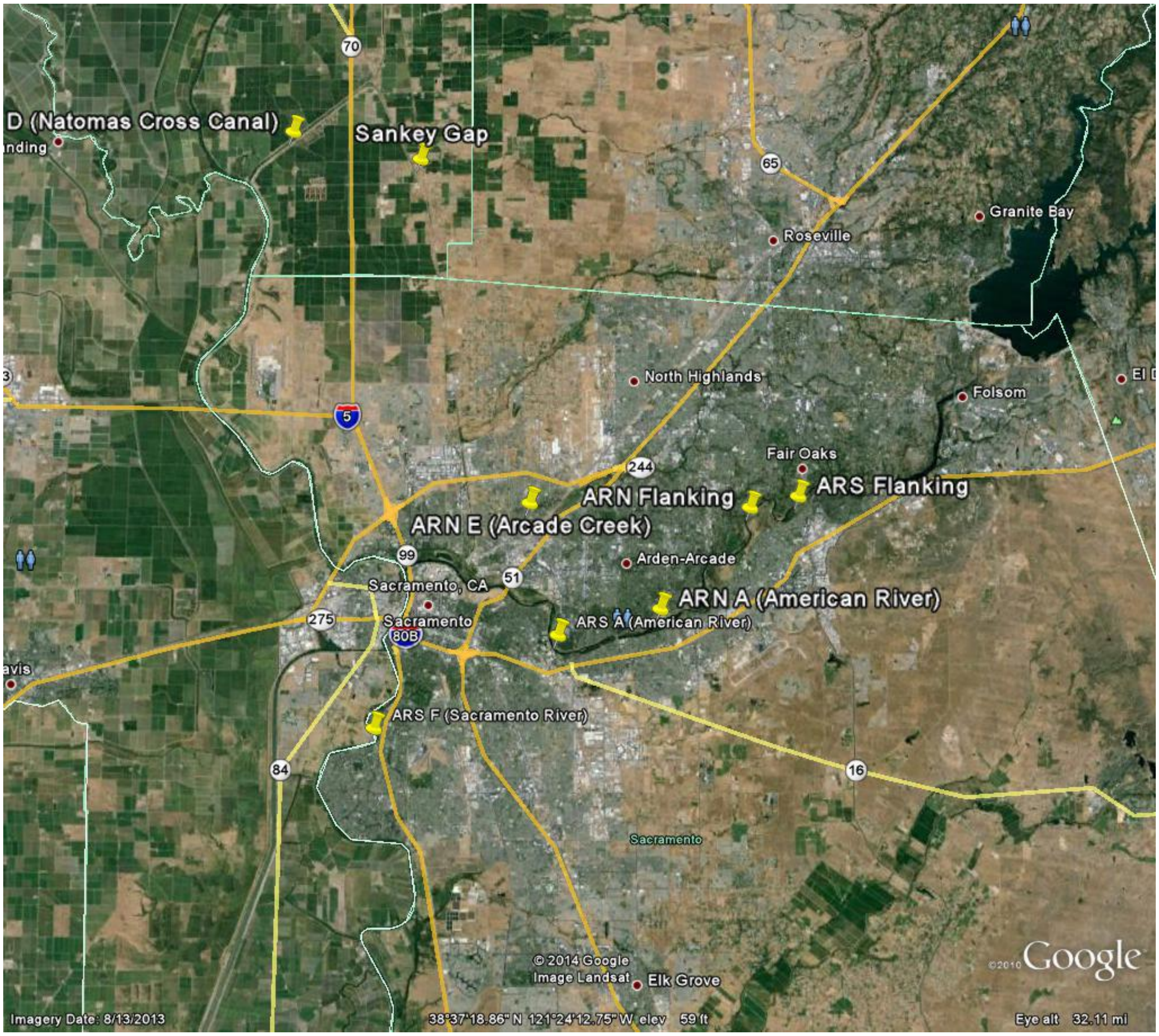


Figure 7: General Location of Eight Index Points Used in the Economic Analysis

In this analysis "representative index points" refers to those locations whereby the without-project condition (damages and performance) of the study area is best characterized. The PDT's intent was to balance rigor with practicality in choosing the number of index points to use in the analysis. Once the number of index points was determined for this GRR – essentially one index point to represent a major source of flooding (per bank side) plus several others to be able to check for residual damages (e.g., outflanking locations on the American River), the PDT then made a preliminary comparison of the chance of flooding and the consequences of flooding – in other words the overall flood risk associated with a levee breach at various locations – in selecting the representative index points. During the course of the study, two of the index points (ARS B and ARS E) that were originally selected were replaced by alternate index points (ARS A and ARS E).

As Table 5 below indicates, there's a relatively high chance of a levee performing poorly in the majority of the smaller reaches that make up the larger increments used in the final analysis. Furthermore, a breach in any of the reaches would result in deep and extensive flooding by filling up the respective basin. Taking into account the chance of flooding and consequences of flooding specific to this study area, an incremental analysis based on a delineation of one reach/increment equal to an entire stretch of river (e.g., the Sacramento River from the confluence with the American River downstream to the boundary of the study area) or an incremental analysis based on a delineation of multiple reaches/increments along a stretch of river (e.g., ARS D, E , F, and G on the Sacramento River from the confluence with the American River downstream to the boundary of the study area) would ultimately arrive at the same conclusion: that benefits/net benefits are maximized once the entire system is improved. Residual risk would remain relatively high until the entire system is improved since flooding from various locations (reaches) affects the same consequence area.

Table 5: Probability of Poor Performance for Various ACE Events

Basin/Reach	Probability of Poor Performance (P(f))		
	2% ACE	**1% ACE**	**Top of Levee (TOL)**
ARS Basin – American River Index Points			
ARS A	~13%	~13%	~65%
ARS B	~20%	~23%	~65%
ARS C	~12%	~16%	~30%
ARS Basin – Sacramento River Index Points			
ARS D	~12%	~16%	~61%
ARS E	~25%	~25%	~45%
ARS F	~30%	~30%	~45%
ARS G	~22%	~28%	~36%
ARN Basin – American River Index Points			
ARN A	~12%	~15%	~56%
ARN B	~6%	~7%	~15%
ARN C	~28%	~45%	~60%

2.7 DESCRIPTION OF ECONOMIC DATA & UNCERTAINTIES

The economic data used in the analysis are described in the following sub-sections. These data lay the groundwork for the without-project damage and with-project benefit analyses that are described in Chapters 3 and 4, respectively.

2.7.1 Structure Inventory

An extensive, comprehensive structure inventory of the study area was performed for the 2008 American River Watershed Folsom Dam Modification and Folsom Dam Raise Economic Reevaluation Report (ERR). The 2008 ERR inventory was carried forward to this analysis with limited updating for price level (all basins) and foundation heights (Natomas Basin).

Structure data was collected using standard USACE practices. For the ERR, a base geographic information system (GIS) inventory with parcel attribute data for both Sacramento and Sutter counties was provided by the non-federal partner. Numerous field visits were taken to collect the base inventory data, including number of stories, foundation heights, building use (residential, commercial, industrial, public), occupancy types (more specific building use, such as commercial restaurant or single-family residential), class (per Marshall & Swift Valuation Service's grades of construction), construction rating (per Marshall & Swift's categories of "low cost" to "excellent" construction), and condition ("poor" to "new" condition), which was used to estimate depreciation.

The data collected for the ERR produced a structure inventory encompassing an area larger than the current 0.2% (1/500) annual chance exceedance (ACE) floodplain for the ARS and ARN basins. Structure counts for the four main building categories are listed in Table 6 below, and represent only those structures falling within the 0.2% (1/500) ACE floodplain.

Table 6: Number of Structures by Category and Basin in Impact Areas Delineated in 2008 ERR

CATEGORY	STRUCTURE COUNT			
	ARS BASIN	ARN BASIN	NATOMAS BASIN	TOTAL
COMMERCIAL	3,210	754	292	**4,256**
INDUSTRIAL	1,064	224	149	**1,437**
PUBLIC	819	147	82	**1,048**
RESIDENTIAL	104,513	14,018	22,247	**140,778**
TOTAL	**109,627**	**15,143**	**22,770**	**147,540**

2.7.2 Structure and Content Values

Structure attribute data collected during field visits and obtained from the non-federal partner were used to determine valuation of structures and contents.

2.7.2.1 Structure Values

For all residential structures classified as single-family residential (SFR), Sacramento County provided detailed information regarding square footage of the buildings. This included total square footage, basement square footage, 2nd-floor square footage, and garage square footage; this same data was not available for the non-residential and multi-family residential (MFR) categories. For many of the larger buildings and in some of the commercially-dense areas, the county provided GIS data that included digitized building footprints. The GIS data was used to identify each structure's square footage. For those buildings not included in the GIS data, high-resolution aerial photographs were used in conjunction with GIS to measure the building footprint. In both cases, the measured first floor square footages were used along with the number of damageable floors (limited to no more than three floors) to estimate the maximum possible damageable square footage for structure valuation purposes.

Depreciated replacement value of structures were estimated based upon building square footage, estimated cost per square foot (from the Marshall & Swift Valuation Handbook), and estimated depreciation. Values per square foot were based on building use, class, and type as outlined in the Marshall and Swift Valuation Handbook.

2.7.2.2 Content Values

For SFR residential structures, depth-percent damage curves developed by the USACE Institute for Water Resources (IWR) and presented in Economic Guidance Memorandum (EGM) 01-03 and 04-01, were used. Since the percentage damages in these generic depth-percent damage curves were developed as a function of structure value, it was unnecessary to explicitly derive content values for input into the HEC-FDA model; the model computes content damages by applying the percentages in the content-percent damage curves to structure values. For report purposes and to estimate content value for residential structures, a content-to-structure value ratio of 50% was used, which is consistent with the ratio used in prior American River Watershed studies. It should be note that the residential content-to-structure value ratio (CSVR) of 0.5 (50%) was used to derive an order of magnitude estimate of the value of damageable property (contents) for reporting purposes only and was not used to estimate actual residential content values for use in the calculation of expected annual damages (EAD) or annual benefits. While it is understood that the 0.5 CSVR cannot realistically be applied broadly to all homes in the study area, it has been used in past District studies as a simple but adequate way to help derive an estimate of the total value of property in the study area and as a way to gage the magnitude of content damages should a flood event occur.

For non-residential categories, an expert elicitation was performed to develop content values and content depth-percent damage curves for specific occupancy types for the 2008 ERR. The results of that expert elicitation were used for this analysis. The values and curves were developed specifically for structures in the American River Watershed study area. In total, there were 22 different occupancy types with values ranging from $22 to $235 per square foot with uncertainty. Content values for non-residential structures were generated as a function of building use, damageable square footage, and content value per square footage per occupancy type. Additional information regarding non-residential dollar-per-square foot values and depth-percent damage curves can be found in the 2008 ERR.

Tables 7, 8 and 9 show the value of damageable property, by basin, for structures, contents, and combined, respectively.

Table 7: Value of Damageable Property (Structures) by Category and Basin in 0.2% Floodplain

CATEGORY	VALUE OF DAMAGEABLE PROPERTY (IN $1,000S, OCTOBER 2015 PRICE LEVEL): STRUCTURES			
	ARS BASIN (ARS A)	ARN BASIN (ARN E)	NATOMAS BASIN (NAT D)	TOTAL
COMMERCIAL	5,758,255	2,181,880	665,735	8,605,870
INDUSTRIAL	2,123,101	433,933	439,682	2,996,716
PUBLIC	5,516,293	633,479	489,049	6,638,821
RESIDENTIAL	18,195,458	2,648,052	4,259,542	25,103,052
TOTAL	**31,593,107**	**5,897,343**	**5,854,008**	**43,344,459**

Table 8: Value of Damageable Property (Contents) by Category and Basin in 0.2% Floodplain

CATEGORY	VALUE OF DAMAGEABLE PROPERTY (IN $1,000S, OCTOBER 2015 PRICE LEVEL): CONTENTS			
	ARS BASIN (ARS A)	ARN BASIN (ARN E)	NATOMAS BASIN (NAT D)	TOTAL
COMMERCIAL	3,095,566	1,052,296	280,247	4,428,109
INDUSTRIAL	1,452,267	364,061	232,758	2,049,086
PUBLIC	1,503,087	201,622	282,486	1,987,195
RESIDENTIAL	9,097,730	1,324,026	2,134,367	12,556,123
TOTAL	**15,148,650**	**2,942,005**	**2,929,857**	**21,020,512**

Table 9: Value of Damageable Property (Structures & Contents) by Category and Basin in 0.2% Floodplain

CATEGORY	VALUE OF DAMAGEABLE PROPERTY (IN $1,000S, OCTOBER 2015 PRICE LEVEL): STRUCTURES & CONTENTS			
	ARS BASIN (ARS A)	ARN BASIN (ARN E)	NATOMAS BASIN (NAT D)	TOTAL
COMMERCIAL	8,853,821	3,234,176	945,982	13,033,979
INDUSTRIAL	3,575,368	797,994	672,440	5,045,802
PUBLIC	7,019,380	835,101	771,535	8,626,016
RESIDENTIAL	27,293,188	3,972,078	6,393,909	37,659,175
TOTAL	**46,741,757**	**8,839,349**	**8,783,865**	**64,364,972**

2.7.3 First-Floor Elevation of Structures

For structure and content damages, depth of flooding relative to the structure's first floor is the primary factor in determining the magnitude of damages. The current analysis uses HEC-FDA's internal processes for the determination of structural inundation. The process combined a geographic information system (GIS) database containing spatially-referenced polygons for each parcel in the study area with water surface elevations (per grid cell) from the FLO-2D modeling. Parcels/structures were then tied to a specific grid cell in which the parcel was located.

A representative ground elevation was assigned to each parcel/structure using GIS. Foundation heights for each structure were estimated during numerous field visits. First-floor elevations were computed in HEC-FDA using the foundation height and ground elevation data.

Using the ground elevation and foundation height data from the economic structure inventory in conjunction with the water surface elevation data from the WSP, depths of flooding above the first floor at each structure for each annual chance exceedance event were computed within HEC-FDA. As explained previously, water surface elevations (WSE) from the FLO-2D modeling were provided for each grid cell for the 0.5, 0.1, 0.04, 0.02, 0.01, 0.005, and 0.002 ACE events and were imported into the HEC-FDA model in the form of a water surface profile.

2.7.4 Emergency Cost Losses

Depreciated replacement values of structures are used to assess structure and content damages and to gage the cost of replacing damaged portions of structures and contents of similar use and condition. However, there are other costs/damages directly associated with structure and content damages that may result from a flood event but which are not captured in the estimate of structure and content damages. These additional damage categories were considered in the assessment of without-project damages and with-project benefits for the American River Common Features GRR, and include:

1. Clean-up costs
2. Temporary evacuation, relocation and housing assistance (TERHA)

The sub-sections below describe in greater detail these additional flood damage/benefit categories. The assessment method used for this report follows the one used in the Sutter Basin Feasibility Study. In the Sutter study, both clean-up and TERHA costs were included in the estimate of without-project damages and with-project benefits. Further, the Sutter study has been approved by the USACE Civil Works Review Board (CWRB) as well as by the Office of the Assistant Secretary of the Army, which adds some legitimacy to both the damage/benefit categories and methodology.

The without-project damages and with-project benefits (alternatives in Final Array) associated with clean-up and TERHA costs are summarized in Table 17 in Section 3.3.2 (without-project condition) and Tables 45-46 in Section 4.10 (without-project and with-project conditions).

Clean-Up Costs: Flood waters leave debris, sediment, salts and the dangers of diseases throughout flooded structures, making the cleaning of these structures a necessary post-flood activity. Clean-up costs for the extraction of flood waters, dry-out, and decontamination vary significantly based upon various factors, including depth of flooding. Studies conducted by both Sacramento and New Orleans Districts indicate a maximum value of ten dollars per square foot ($\$10/ft^2$) for such clean-up costs. This maximum per square foot cost covers clean-up costs associated with mold and mildew abatement, which entails having professional firms apply fans, chemicals, and other techniques to eliminate and prevent mold/mildew in inundated areas. The maximum clean-up cost of $\$10/ft^2$ was used for the American River Common Features economic assessment and was applied for flood depths equal to and exceeding five feet, with damage percentages scaled down for depths between zero and five feet. Figure 8 below displays per square foot clean-up costs as a function of flood depths; Figure 9 displays the depth-percent damage curve used in the HEC-FDA analysis.

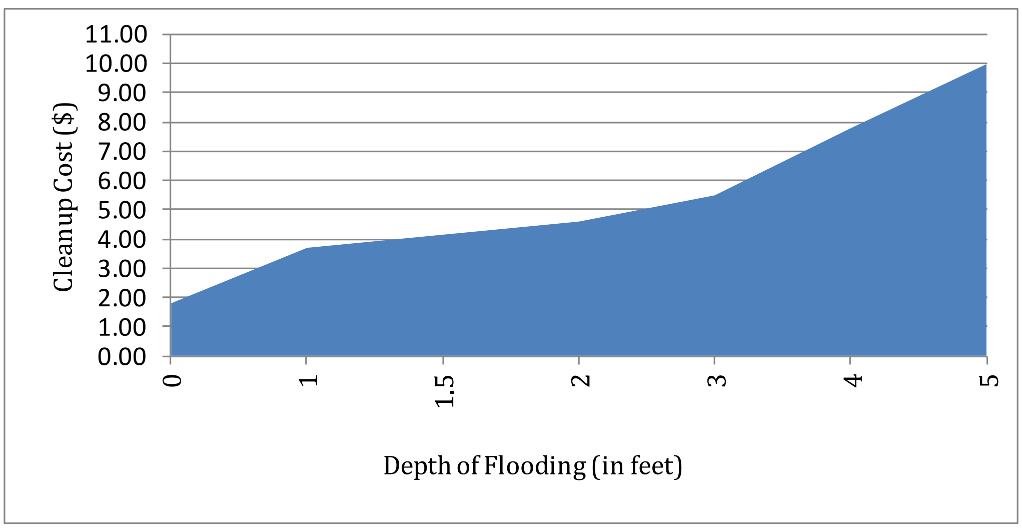


Figure 8: American River Common Features GRR, Dollar-Per-Square Foot Clean-Up Costs as a Function of Depth of Flooding

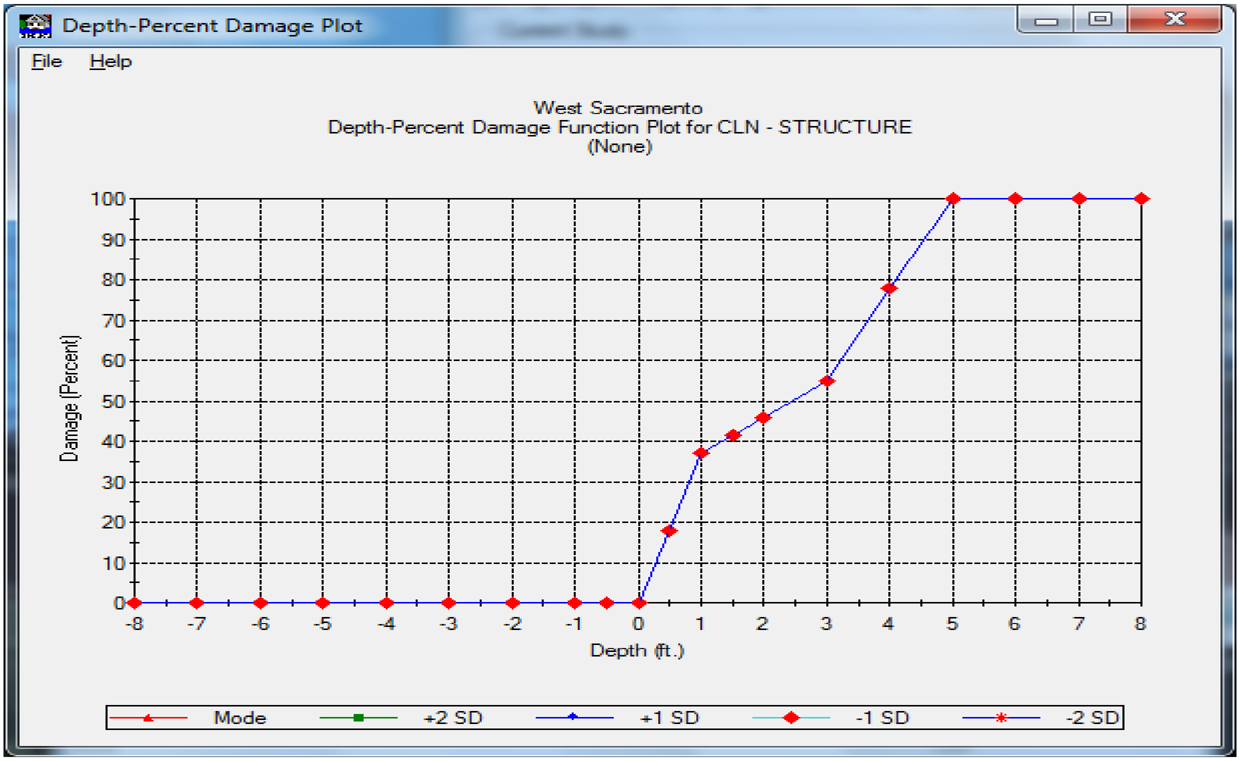


Figure 9: American River Common Features GRR, Depth-Percent Damage Curve for Clean-Up Costs Used in HEC-FDA Analysis

Temporary Evacuation, Relocation, and Housing Assistance (TERHA): ER 1105-2-100 states, "Flood damages are classified as physical damages or losses, income losses, and emergency costs." The ER then defines emergency costs as "those expenses resulting from a flood what would not otherwise be incurred…" The ER further requires that emergency costs should not be estimated by applying an arbitrary percentage to the physical damage estimates.

The Federal Emergency Management Agency (FEMA) provides grants to assist individuals and families to find suitable housing when they are displaced in cases of federally declared disasters. The program assures that people have a safe place to live until their homes can be repaired. This assistance is directly attributable to the disaster, since it is an expenditure that is only undertaken when a disaster occurs. Therefore, it falls under the emergency cost guidance of ER 1105-2-100, and the funds expended by FEMA for temporary evacuation, relocation, and housing assistance (TERHA) in the event of a flood are a legitimate flood damage category under the NED account.

Cost estimates for the relocation and emergency services provided to floodplain residents displaced during peak flood events and post-flood structural renovations were based on FEMA's methodology for evaluating TERHA costs. This methodology relates TERHA costs to relocation costs, structure damage percentages and the number of days residents spend displaced from their structures. The maximum TERHA costs of $11,244 correspond with one year of FEMA evacuation, relocation and/or housing assistance costs. These costs are based on the median rent of a two bedroom apartment, and were derived for this assessment using rent prices in the Sacramento area as posted on the website www.rent.com. The maximum cost of $11,244 was applied to structures sustaining at least 50 percent damage, with scaled down costs being computed for less damaging flood events. Figure 10 below shows percent of maximum TERHA damages as a function of the depth of flooding. The depth-percent damage relationship for a one-story single family residential (SFR) structure is also shown as a point of reference; however, unique depth-percent damage relationships for one-story residential, two-story residential, and mobile homes were applied in HEC-FDA to derive damages and benefits for TERHA.

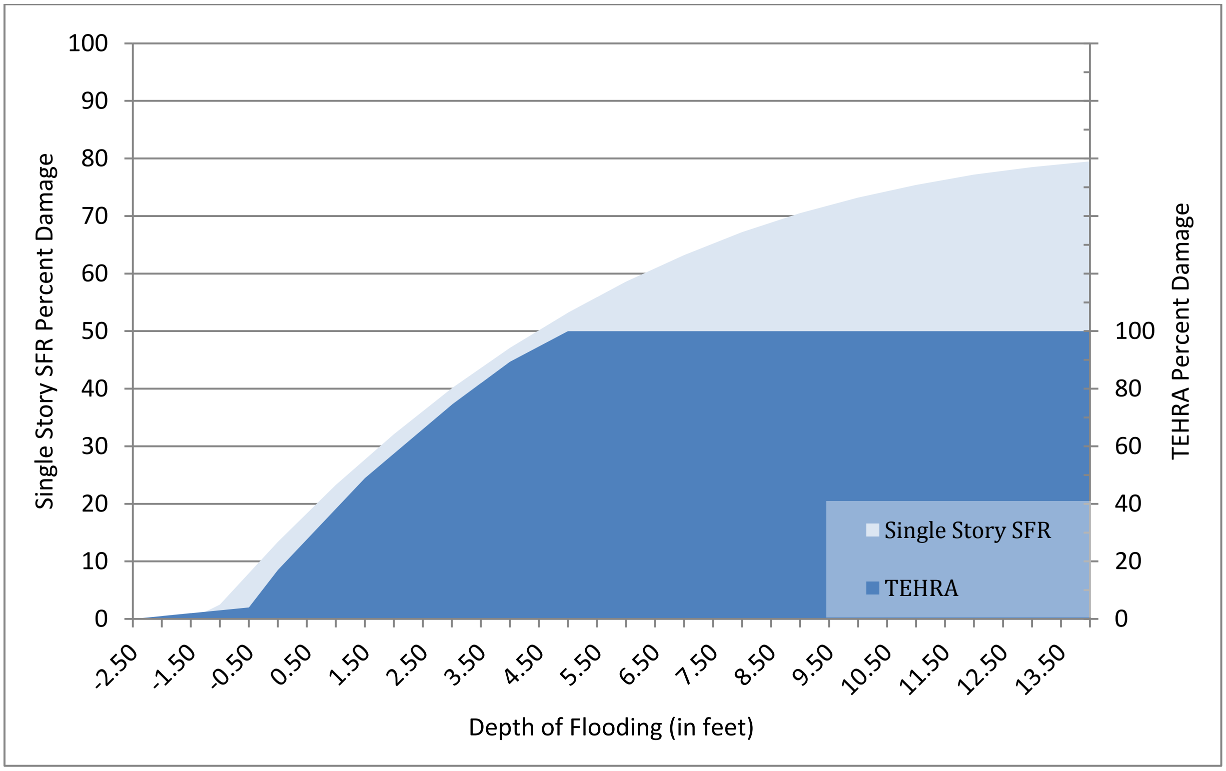


Figure 10: American River Common Features GRR, Depth-Percent Damage Curve for TERHA Overlaid onto Depth-Percent Damage Curve for One-Story Residential

2.7.5 Automobiles

In the 2010 Natomas Post-Authorized Change and Interim Reevaluation Report (NPACR) an average automobile value of $7,988 was obtained from the Bureau of Transportation Statistics. This value was updated for price level ($8,308) and used in this analysis.

The number of cars impacted was based on the number of cars per residential unit (1.93), which in turn was based on the total number of automobiles and trucks registered in the Sacramento Area (source: California Department of Finance) divided by the number of households. Automobile counts for car dealerships were based on discussions with local dealers and comparisons with spot inventories from aerial photos. The analysis assumed that, based on relatively short evacuation times, about 50% of residential-based vehicles would be removed from the flood area prior to the event and only 20% would be removed from dealerships. This is consistent with EGM 09-04, which recommends a removal rate of 50.6% for areas where the warning time is less than 6 hours.

Table 10 displays the estimated value of automobiles in the 0.2% annual chance exceedance (500-year) floodplain.

Table 10: Value of Damageable Property (Automobiles) by Category and Basin in 0.2% Floodplain

CATEGORY	VALUE OF DAMAGEABLE PROPERTY: AUTOMOBILES (IN $1,000S, OCTOBER 2015 PRICE LEVEL)			
	ARS BASIN (ARS A)	ARN BASIN (ARN E)	NATOMAS BASIN (NAT D)	TOTAL
AUTOMOBILES	1,408,337	274,254	186,905	**1,869,496**

2.7.6 Depth-Percent Damage Curves

The depth of flooding is the primary factor in determining potential damages to structures, contents, and automobiles. Depth-percent damage functions were used in the HEC-FDA models to estimate the percent of value lost for these categories. Residential depth-damage curves (structures and contents) were taken from Economic Guidance Memorandum (EGM) 01-03, *Generic Depth-Damage Relationships,* and 04-01, *Generic Depth-Damage Relationships for Residential Structure with Basements,* for use on both single-family and multi-family residential structures. Structures were identified as 1-story, 2-story, or split-level. Mobile home curves were taken from the May 1997 Final Report, *Depth Damage Relationships in Support of Morganza to the Gulf, Louisiana Feasibility Study*. Non-residential structure curves were based on revised Federal Emergency Management Agency (FEMA) Flood Insurance Administration (FIA) curves. Two sets were used: 1) standard FEMA FIA curves for impact areas with shorter-duration flooding and 2) adjusted curves for areas where inundation depths are deep and flooding durations are long (exceeding three days); these curves were based on the prior Natomas Basin studies and the 1997 Morganza Study. As previously described in Section 2.7.2.2, non-residential content depth-percent damage curves for 22 occupancy types were developed based on an expert elicitation; these curves were developed specifically for building types in the Sacramento area and for American River Watershed analyses.

Depth-percent damage functions for automobiles were based on averages from curves developed by the Institute for Water Resources (IWR) and provided in EGM 09-04, *Generic Depth-Damage Relationships for Vehicles*.

All of the depth-percent damage curves used in the analysis can be found in the American River Common Features GRR HEC-FDA models.

2.7.7 Economic Uncertainties

The valuation of residential and non-residential structures and contents along with automobile losses were estimated with uncertainty. In the estimation of structure value, three variables were considered to have a possible range of values: 1) dollar per square foot 2) building square footage and 3) percent of estimated depreciation. Using triangular distributions to describe the range of these three variables, a Monte Carlo simulation was run on typical structures by category and the mean and standard deviations were compared to derive coefficients of variation (COV) for structure values by category. Content value uncertainties for non-residential structures were based on data from the expert elicitation mentioned previously. The program Best Fit was used to determine what would be a reasonable distribution, and using the model data, it was determined that a normal distribution best described uncertainty in the structure and content valuation. These uncertainty parameters for valuation were imported into the HEC-FDA program.

Several factors contributed to the uncertainty associated with automobile damages. These factors include the average unit value, the number of vehicles per residence/dealership assumed, and the evacuation rate. It was assumed that the average number or automobiles per residential unit was about 2 and the evacuation rate was 50%. An average value of an automobile was determined to be $8,308. While uncertainty in these variables was not considered, uncertainty in the percent damage by depth (as reflected in the depth-percent damage curve) was taken into account.

Uncertainty in first floor elevation was also included in the model. During the field inventory, first floor (foundation height) estimates were made by visual inspection and assigned to structures in one half-foot increments. For example, the average SFR built on slab without any fill might be listed as ground elevation + 0.5 foot to 1.0 foot; raised foundations either 1.5, 2 or 2.5 feet. Based on this level of precision, it was assumed that 0.5 foot standard deviation would capture the potential uncertainty in this first floor elevation adjustment.

The uncertainty associated with the percent damages at specific depths of flooding for automobiles and structures/contents were entered into the HEC-FDA model. Residential structure and content depth-percent damage curves are normally distributed and include standard deviations of percent damages by depth of flooding. Non-residential content depth-percent damage curves are triangularly distributed and include a minimum, most likely, and maximum percent damage by depth of flooding.

All of the value and depth-percent damage uncertainty associated with structures, contents and automobiles can be found in the American River Common Features GRR HEC-FDA models.

2.8 DESCRIPTION OF ENGINEERING DATA & UNCERTAINTIES

The following sub-sections briefly describe the engineering data used in the economic analysis. More details about each discipline-specific engineering analysis can be found in the following appendices: Appendix B – Hydrology, Appendix C – Hydraulics, and Appendix F – Geotechnical.

2.8.1 Hydrologic Engineering Data Used in HEC-FDA

The Sacramento District's Water Management Section provided the hydrologic data used in the HEC-FDA modeling. This includes the equivalent record length at each index point, the exceedance probability-discharge curve or the statistics required to compute the exceedance probability-discharge curve in HEC-FDA (depending on the index point), and the transform flow curves for those index points on the American River, where outflow is regulated by operations at Folsom Dam. These data and curves can be found in the Hydrologic Engineering Attachment in the Main Engineering Report or in any of the American River Common Features GRR HEC-FDA models.

2.8.2 Hydraulic Engineering Data Used in HEC-FDA

The SPK Hydraulic Design Section used the HEC-RAS model to determine stages in the channel, to model levee breakout locations, and to develop breakout hydrographs; it used the FLO-2D model to determine water surface elevations in the floodplain (i.e., develop suites of floodplains). More details about the data and assumptions used by the Hydraulic Design Section for their HEC-RAS and FLO-2D modeling efforts can be found in the Hydraulic Design Attachment to the Main Engineering Report.

For this analysis, a suite of floodplains was generated for each of the eight index points. For each index point, the Hydraulic Design Section provided data for input into the HEC-FDA model. These include:

- Discharge-stage (rating) curves with uncertainty for the without-project and with-project conditions for four index points (those on the American River)
- Exceedance probability-stage curves with uncertainty for the without-project and with-project conditions for three index points (NAT D, ARS F, and ARN E)
- Suites of floodplains for each index point; these were formatted from FLO-2D water surface elevation data for direct import into HEC-FDA

2.8.3 Geotechnical Engineering Data Used in HEC-FDA

A geotechnical levee fragility curve shows the probabilities of failure at different water surface elevations against a levee. Fragility curves are a main component of the economic modeling and in determining the performance of a project, which is often described in terms of annual exceedance probability (AEP) or the chance of flooding in any given year.

For this analysis, five sets of geotechnical levee fragility curves were used in the economic analysis, one set for each index point located on a levee reach, with each set including a without-project and with-project curve. (Since there are no levees on the upper portion of the Lower American River or at the Sankey Gap, no fragility curves associated with these three index point locations were developed.) The levee fragility curves used in the economic analysis can be found in the American River Common Features GRR HEC-FDA models. The Geotechnical Engineering Attachment in the Main Engineering Report describes in detail the development of these curves.

2.8.4 Engineering Uncertainties in HEC-FDA

There were three main engineering uncertainties incorporated into the HEC-FDA modeling:

- Uncertainty in within-channel discharges was computed in HEC-FDA using data provided by the District's Water Management Section. This data was in the form of either an equivalent record length (for graphical curves) or Log Pearson Type III Statistics (for analytical curves). In both cases, the data is entered into HEC-FDA, which uses the data to compute uncertainty in discharge for a range of exceedance probability events.
- Uncertainty in discharges from Folsom Dam was accounted for in HEC-FDA by using transform flow (regulated versus unregulated) curves containing minimum values and maximum values around the regulated discharges for a range of exceedance probability events.
- Uncertainty in stages (in-channel) was captured in the hydraulic rating curves, which were entered into HEC-FDA. Stage uncertainty was provided by the District's Hydraulic Design Section.

All of the data used to describe the uncertainty in the main engineering relationships can also be found in the Common Features GRR HEC-FDA models or in the respective engineering attachments to the Main Engineering Report.

CHAPTER 3
WITHOUT-PROJECT ANALYSIS & RESULTS:
AUTHORIZED COMMON FEATURES + JOINT FEDERAL PROJECT + DAM RAISE

3.1 FUTURE WITHOUT-PROJECT CONDITION

Expected annual damages (EAD) and engineering project performance results for the without-project condition, which assumes that the WRDA 1996/1999 Authorized Common Features Project, the Joint Federal Project (JFP), and the Folsom Dam Raise Project are in place and operational, are summarized in this chapter. The without-project condition serves as the baseline for which all with-project alternatives are measured against. The with-project alternatives analysis is presented in Chapter 4.

3.2 FLOODING CHARACTERISTICS

The without-project analysis and results are based predominantly on estimates of the flooding extent, the depth of flooding, and the property that may be damaged from flooding within a particular area. Tables 11 to 13 display key characteristics of flooding associated with specific annual chance exceedance events for the three basins within the study area. The flooding characteristics of a basin may differ depending on the assumed levee breach location (reach/index point). For example, structures in the Natomas Basin (NAT D breach location) would experience significant flooding above the first floor elevation; the average depth of flooding above the first floor exceeds 10 feet, even for relatively higher frequency events such as the 25-year. In the ARS basin, average depth of flooding above the first floor exceeds 6 feet (ARS F breach location) for the 25-year event. In all basins, flooding would be deep and potentially catastrophic.

It is important to note that it would be incorrect to sum the number of structures inundated per index point within a basin to derive a total number of structures at risk (Tables 11 to 13 below); this would result in double counting. The same structures may in fact be at risk from flooding from more than one location (index point). For example, in the Natomas Basin and the ARS Basin, flooding from one location (ARS A and NAT D) will result in essentially the entire inventory extent for the respective basin (i.e., flooding from ARS A essentially includes all structures in the south basin and flooding from NAT D includes all structures in the Natomas Basin); on the other hand, in the ARN Basin there is substantial overlap between flooding that occurs from ARN A and from ARN E, but flooding from either does not totally encompass the full structure inventory for the ARN Basin. Estimates of the total number of structures at risk from flooding in each basin were presented in Chapter 2.

Plates displaying the full suite of floodplains for each of the index points are located in the Hydraulic Design Attachment of the Main Engineering Report.

Table 11: Flooding Characteristics by Index Point and Annual Chance Exceedance (ACE) Event Floodplains Under Levee Breach Scenario: ARS Basin

REACH/INDEX POINT	AVERAGE DEPTH OF FLOODING ABOVE 1ST FLOOR BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT (IN FEET)			NUMBER OF STRUCTURES INUNDATED BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT		
	0.04	0.01	0.002	0.04	0.01	0.002
A	1.6	4.1	6.7	11,405	23,888	109,627
FLANKING	0	0	5.8	0	0	95,560
F	6.7	7.0	7.6	37,759	49,374	96,019

Table 12: Flooding Characteristics by Index Point and ACE Event Floodplains Under Levee Breach Scenario: ARN Basin

REACH/INDEX POINT	AVERAGE DEPTH OF FLOODING ABOVE 1ST FLOOR BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT (IN FEET)			NUMBER OF STRUCTURES INUNDATED BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT		
	0.04	0.01	0.002	0.04	0.01	0.002
A	4.4	7.1	7.7	8,009	13,437	14,837
FLANKING	0	0	6.4	0	0	13,758
E	4.1	3.9	8.1	2,247	3,346	15,143

Table 13: Floodplain Characteristics by Index Point and ACE Event Floodplains Under Levee Breach Scenario: Natomas Basin

REACH/INDEX POINT	AVERAGE DEPTH OF FLOODING ABOVE 1ST FLOOR BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT (IN FEET)			NUMBER OF STRUCTURES INUNDATED BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT		
	0.04	0.01	0.002	0.04	0.01	0.002
D	10.0	12.2	17.6	22,547	22,677	22,770
SANKEY GAP	0	0	1.8	0	0	2,821

A full set of floodplain plates can be found in the Hydraulic Design Appendix. These include floodplains for a range of events (2yr to 500yr) and for each index point.

3.3 FLOOD RISK: PROBABILITY & CONSEQUENCES

Risk can be described in terms of the chance of some undesirable event occurring and the potential consequences should that undesirable event occur. In FRM National Economic Development (NED) analysis, risk is described in terms of the chance of flooding (the undesirable event) and the potential damages (consequences) from flooding. The following sections describe the flood risk associated with the without-project condition.

3.3.1 Annual Chance Exceedance (ACE) Event Damages

Annual chance exceedance (ACE) event damages, sometimes referred to as single-event damages, were computed in HEC-FDA. Single-event damages assume that a breach from a specific probability event occurs; it does not take into account the likelihood of this event actually happening. Single-event damages are useful in that they show the magnitude of consequences, within a particular consequence area, *should* a specific flood event occur in that area. Table 14 below shows the damages that may occur for a range of events within the three main basins. These damage values include automobiles, structures, and contents, and represent damages based on flooding from one index point per basin – ARN A in the north basin, ARS F in the south basin, and NAT D in the Natomas Basin. While damages reported in the table for the ARS basin are based on flooding from the ARS F location, it should be noted that flooding from a 0.2% ACE event (500-year) from the ARS A location on the American River would result in greater damages to the ARS basin – about $24.6 billion in damages – than sustained at the ARS F location ($21.6 billion).

Table 14: Damages by Annual Chance Exceedance Event

BASIN	ACE EVENT DAMAGES (IN $1,000s, OCTOBER 2015 PRICE LEVEL)						
	50%	10%	4%	2%	1%	.5%	.2%
ARS (F)	6,660,369	8,427,409	8,427,409	9,197,846	13,302,749	14,288,782	21,612,855
ARN (A)	0	0	2,824,045	2,908,650	4,654,995	4,970,941	5,456,034
NATOMAS	4,404,922	5,579,812	5,784,706	6,109,155	6,271,056	6,403,807	6,896,591
TOTAL	**11,065,291**	**14,007,221**	**17,036,160**	**18,215,651**	**24,228,800**	**25,663,530**	**33,965,480**

3.3.2 Expected Annual Damages (EAD)

Expected annual damage (EAD) is the metric used to describe the consequences of flooding on an annual basis considering a full range of flood events – from high frequency/small events to low frequency/large events over a long time horizon (years). It is the main economic statistic used to describe the flooding problem in the study area; it is also used as the baseline to measure potential benefits from proposed FRM alternatives.

Table 15 displays the EAD results for each index point and by major damage category. Table 16 condenses the information from Table 15 and displays the EAD results by basin. Since the economic incremental analysis is being performed from a system perspective, the basin EAD results in Table 15 were used as the baseline without-project damages (per each basin) for which to measure with-project outputs.

For the ARS basin, the without-project EAD used as the starting point for the economic analysis is the EAD associated with the index point (per basin) that produced the highest without-project EAD. This is index point ARS F on the Sacramento River.

For the ARN basin, the without-project EAD used as the starting point for the economic analysis is the sum of the EADs associated with the ARN A (American River) and the ARN E (Arcade Creek) index points. Based on information from the SPK Hydraulic Design Section, the American River and Arcade Creek are uncorrelated from both a hydrologic and hydraulic perspective.

For the Natomas Basin, the without-project EAD used as the starting point for the economic analysis is the EAD associated with the NAT D index point. In the prior 2010 NPACR analysis, EAD for Natomas was computed using the HEC-FDA model as well as a supplemental model (N@RM) that accounted for flood plain occupant behavior. The N@RM model was used to adjust EAD results obtained from HEC-FDA by taking into account reduced inventory, reduced value of damageable property, and a decrease in the number of flood plain occupants as floods occurred over time. The adjustment factor using the N@RM model turned out to be, on average, around 67% (i.e., 67% reduction in damages). This factor was carried forward to the current analysis; the EAD results for the Natomas Basin presented in the following tables reflect adjusted values.

Table 15: Without-Project EAD by Index Point

INDEX POINT	WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES (EAD) (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	AUTOS	COMMERCIAL	FARM	INDUSTRIAL	PUBLIC	RESIDENTIAL	TOTAL
ARS A	4,171	15,338	30	3,704	11,760	56,327	**91,330**
FLANKING	806	2,898	3	1,121	2,051	9,858	**16,737**
ARS F	15,080	42,514	395	11,197	35,644	227,555	**332,383**
ARN A	2,171	18,967	0	5,257	4,937	19,796	**51,128**
FLANKING	206	1,702	0	476	535	2,077	**4,995**
ARN E	1,050	8,416	0	4,044	2,023	10,642	**26,175**
NAT D	863	3,294	36	2,328	2,774	19,300	**28,595**
S. GAP	87	0	0	0	36	913	**1,036**

Table 16: Without-Project EAD by Basin

BASIN	WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES (EAD) (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	AUTOS	COMMERCIAL	FARM	INDUSTRIAL	PUBLIC	RESIDENTIAL	TOTAL
ARS	15,080	42,514	395	11,197	35,644	227,555	**332,383**
ARN	3,221	27,383	0	9,301	6,960	30,438	**77,303**
NATOMAS	863	3,294	36	2,328	2,774	19,300	**28,595**
TOTAL	**19,164**	**73,191**	**431**	**22,826**	**45,378**	**277,293**	**438,281**

Emergency cost losses: Expected annual damages (EAD) under the without-project condition were computed using HEC-FDA. For the ARS Basin, damages were computed using the engineering data from Index Point ARS F (Sacramento River), since this location serves as both the starting point for measuring without-project damages and the ending point for measuring with-project residual damages in the incremental analysis presented in Chapter 4. For the ARN Basin, damages were computed using the engineering data from Index Points ARN A (American River) and ARN E (Arcade Creek). The Emergency Cost analysis was performed after the determination of the Final Array of Alternatives. Since none of the alternatives include the Natomas Basin, the emergency cost analysis did not include the Natomas Basin. More information about the Final Array of Alternatives is presented in Chapter 4.

Table 17 below display the results of the HEC-FDA analysis. Expected annual damages associated with clean-up activities are estimated to be approximately $44 million; EAD associated with TERHA is estimated to be approximately $21.5 million. Total EAD for both emergency cost categories combined is estimated to be around $65 million.

Table 17: Without-Project EAD -- Emergency Cost Losses (Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

Emergency Loss Category	Without-Project Expected Annual Damages (EAD)		
	ARS Basin	ARN Basin	Total
Clean-UP	36,860	6,893	43,753
TERHA	17,933	3,566	21,499
Total	**54,792**	**10,459**	**65,251**

Table 18 below summarizes the total without-project EAD by basin and category. It includes all damage categories (structures and contents, automobiles, and emergency cost losses) but does not include the Natomas Basin, which was ultimately removed from the analysis (see Chapter 4). An EAD of approximately $475 million was used as the basis to measure benefits of the proposed alternatives.

Table 18: Total Without-Project EAD by Basin and Category (Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

Total Without-Project EAD by Basin and Category			
Category	ARS Basin	ARN Basin	Total
Structures and Contents	317,303	74,082	391,385
Automobiles	15,080	3,221	18,301
Emergency Costs	54,792	10,459	65,251
Total	387,175	87,762	474,937

3.3.3 Annual Exceedance Probability (AEP) by Index Point and Basin

Annual exceedance probability (AEP) is a statistic used to describe the chance of flooding in any given year within a designated area. It is often used to describe one aspect of flood risk, with the other being the consequences (e.g., damages and loss of life) of flooding. Annual exceedance probability is computed in HEC-FDA using engineering data at an index point; these input data include exceedance probability-discharge, stage-discharge, and geotechnical levee failure relationships, and in some cases transform flow (inflow-outflow discharges associated with dams/reservoirs) curves.

Table 19 below displays the AEP values associated with each index point. Annual exceedance probability values differ depending on the location along the levee due primarily to the differing geotechnical conditions of the levees protecting the basin. Each basin is considered to be protected by a system of levees, and flooding to the basin could potentially occur from various sources. For example, in the ARS Basin, flooding can occur from the American River or the Sacramento River; further, the risk of flooding along either river varies depending on the location along the river. In this respect, the AEP values listed in Table 19 for each index point represent the probability of a flood event occurring when considering only one failure location (one failure mechanism). Generally, evaluating AEP information at multiple points at which flooding into an area could occur typically provides a more complete characterization of the chance of flooding for that particular area.

Table 19: Annual Exceedance Probability (AEP) by Index Point -- Without-Project Condition

BASIN	INDEX POINT	AEP	1/AEP
ARS	ARS A	0.0103	1 in 97
	ARS Outflanking	0.0034	1 in 294
	ARS F	0.0310	1 in 32
ARN	ARN A	0.0104	1 in 96
	ARN Outflanking	0.0010	1 in 1000
	ARN E	0.0165	1 in 61
NATOMAS	NAT D	0.0150	1 in 67
	Sankey Gap	0.2070	1 in 5

3.3.4 Long-Term Risk by Index Point and Basin

Another statistic that the HEC-FDA program computes is long-term risk. Long-term risk describes the chance of flooding over a given time period, such as 30 years; HEC-FDA computes long-term risk statistics for 10-, 30-, and 50-year periods. Table 20 displays the without-project long-term risk results for each index point/basin. For each basin, the long-term risk over a 30-year period is relatively high and exceeds 25%.

Table 20: Long-Term Risk by Index Point/Basin -- Without-Project Condition

BASIN	INDEX POINT	LONG-TERM RISK		
		10 YEARS	30 YEARS	50 YEARS
ARS	ARS A	10%	27%	41%
	Outflanking	4%	11%	18%
	ARS F	27%	61%	79%
ARN	ARN A	10%	27%	41%
	Outflanking	1%	3%	4%
	ARN E	15%	39%	57%
NATOMAS	NAT D	9%	36%	52%
	Sankey Gap	90%	99%	99%

3.3.5 Assurance

Assurance, formerly known as conditional non-exceedance probability (CNP), describes the likelihood of a stream/river being able to pass a specific flow event, for example the 100-year flow. The assurance statistics provide relevant information to decision makers in that it helps describe both how well the flood system currently performs and how well the system could potentially perform under various with-project scenarios.

The assurance statistics for each index point/basin under the without-project condition are listed in Table 21 below. Taking ARS B index point as an example, the information indicates that there is an 84% assurance of passing the 4% flow event, but a lower 75% assurance of passing the 1% flow event.

Table 21: Assurance by Index Point -- Without-Project Condition

BASIN	INDEX POINT	ASSURANCE		
		4%	1%	0.2%
ARS	ARS A	93%	77%	18%
	Outflanking	99%	80%	9%
	ARS F	75%	69%	24%
ARN	ARN A	92%	75%	22%
	Outflanking	99%	98%	40%
	ARN E	90%	68%	7%
NATOMAS	NAT D	93%	84%	37%
	Sankey Gap	3%	1%	1%

CHAPTER 4
WITH-PROJECT ALTERNATIVES ANALYSES

4.1 WITH-PROJECT ANALYSIS: BASIN AS BASIC ANALYTICAL UNIT

Without-project expected annual damages were computed at eight representative index points throughout the study area. As was explained in Chapter 2, the project delivery team (PDT) selected these index points, which are located on the main flood sources, in order to be able to reasonably characterize the flood risk associated with each of the three main basins by accounting for the multiple sources of flooding in each basin.

Similarly, with-project damages reduced (benefits) associated with various project alternatives were also computed at each representative index point for each basin. If the flood risk in a basin (or any other consequence area) could be attributed to one and only one flood source, then the total benefits computed at an index point along a particular flood source would represent the benefits of building a project on that flood source. This is not the case, however, for the Common Features study area as flood risk in each basin/consequence area can be attributed to multiple flood sources. Under this scenario, benefits were computed first at each index point (source), and then estimated for the whole basin using the appropriate calculation method as determined by assessments of the hydrologic/hydraulic correlation between the flood sources within a basin. Table 22 below summarizes the methods used to estimate benefits for each basin.

It should be pointed out that while the results for the Natomas Basin are presented in some of the following tables, the Natomas Basin is not part of any alternative in the Final Array. Therefore, any potential benefits associated with improvements to the Natomas Basin are not included in the final net benefit analysis. Section 4.7 discusses the rationale for leaving out the Natomas Basin from each of the alternatives as well as the implications of this decision on residual risk in the basin.

Table 22: Method of Benefit Calculation by Basin

BASIN	INDEX POINT	METHOD USED TO ESTIMATE BENEFITS
ARS	A	Compare risk at multiple index points and use highest EAD/residual EAD to estimate benefits (A and F)
	Flanking	
	F	
ARN	A	Compute risk at multiple index points and add EADs using joint probabilities (A and E)
	Flanking	
	E	
NAT	D	Estimate benefits using single index point (D) and information from prior analysis (NPACR)
	Sankey Gap	

4.2 DESCRIPTION OF FINAL ARRAY OF ALTERNATIVES

At the start of the plan formulation process, the project delivery team (PDT) assessed an Initial Array of alternatives. This array was then narrowed down to a Focused Array of alternatives (Table 23), which was evaluated in more detail. The alternatives in the Focused Array are described in the following paragraphs below, with the decision whether or not to carry forward each alternative into the Final Array. More detail about the Initial and Focused Arrays of Alternatives is presented in the GRR (Chapter 3).

- **Alternative 0.5** – Improve levees within the existing geometry (Minimum Plan): This alternative would incorporate levee improvements for seepage, stability and erosion but not include any levee raises or other conveyance improvements. This is considered to be the minimum amount of levee improvements needed to substantially reduce the flood risk.

- **Alternative 1** – Improve levees: Focused Alternative 1 adds levee raising to the previous alternative. Focused Alternative 1 involves the construction of in-place levee improvement measures to address seepage, slope stability, erosion, and overtopping concerns identified for the American and Sacramento River levees, NEMDC, Arcade, Dry/Robla, and Magpie Creeks.

- **Alternative 2** – Improve levees and widen Sacramento Weir and Bypass: Focused Alternative 2 adds widening of the Sacramento Weir and Bypass which negated the need to include most of the levee raising in Focused Alternative 1. It accomplished this by rerouting flow that would have gone down the Sacramento River instead to the widened Sacramento Weir and Bypass. The levees along the American River, NEMDC, Arcade, Dry/Robla, and Magpie Creeks would be improved to address identified seepage, stability, erosion, and height concerns through the methods described under Alternative 1. The levees along the Sacramento River would be improved to address identified seepage, stability, erosion, and overtopping concerns through the measures described under Alternative 1.

- **Alternative 3** – Improve levees and construct I-Street diversion structure: Focused Alternative 3 would include the construction of a diversion structure just upstream of the existing I-Street Bridge on the Sacramento River. This diversion structure would restrict flows going down the Sacramento River past the cities of Sacramento and West Sacramento, and would cause a large portion of the flows from the Sacramento and American Rivers to be forced upstream through the Sacramento Bypass out to the Yolo Bypass. The Sacramento Bypass and Weir would be widened to accommodate the increased flows to the bypass system. The effect of this diversion structure would be to reduce the water surface elevation of the Sacramento River downstream of the structure to the point at which seepage, stability, height, and erosion improvements would not be needed.

- **Alternative 4** – Upstream storage on the American River: This alternative involves construction of a flood control dam near the town of Auburn on the north fork American River for the purpose of attenuating flows continuing downstream into Folsom Reservoir and the lower American River. Additionally, levee improvements to address seepage, stability, erosion, and overtopping concerns are included where they exist in various stretches of levee protecting the city of Sacramento.

- **Alternative 5** – Maximum Plan: This alternative would reduce flood risk to the city of Sacramento and the surrounding area and would include most of the measures previously discussed, including levee improvements from Alternative 1, the Sacramento Weir and Bypass widening of Alternative 2, the I-Street Diversion Structure from Alternative 3, and the Auburn Dam from Alternative 4.

- **Alternative 6** – Non-structural: The non-structural alternative would consist of measures such as raising or relocating structures where practical and economically feasible. Also, flood proofing critical infrastructure features and individual structures where inundation depths are lower may be an efficient means of reducing flood risk.

Table 23: Summary of Focused Array of Alternatives

Focused Alternative	Evaluation Summary	Carried Forward?
0.5. Improve Levees within Existing Geometry (Minimum Plan)	This alternative does not maximize net benefits and is on the rising portion of the net benefits curve. It was therefore dropped from further consideration.	No
1. Improve Levees	Improving the existing levees to address seepage, stability, erosion and height issues is the first increment to reducing flood risk for the Sacramento area. Because this alternative increases system performance and appears to have the highest net benefits, it was carried forward for further consideration.	Yes
2. Improve Levees & Widen Sacramento Weir and Bypass	This alternative reduces the flood risk to the urbanized area and has high net benefits and is therefore carried forward for further evaluation. This is the sponsor supported plan.	Yes
3. Improve Levees and Construct I-Street Diversion Structure	This alternative is not efficient. Does not meet worst-first implementation strategy. The implementation sequencing would leave the densely populated areas of Sacramento at risk of flooding until the end of the construction timeframe. The Yolo and Sacramento Bypass levee work would be constructed first in order to accept the higher flows associated with this alternative. Once this was completed, then work on the diversion structure itself would begin. Since no levee work is recommended on the Sacramento river levees as part of this alternative, this high risk area would remain exposed throughout implementation of the project.	No
4. Upstream Storage on American River	Construction of an upstream storage facility does not address the high frequency flood risk associated with the poor performance of levees in the study area. It also does not reduce the risk for the highest risk area along the Sacramento River since this is dominated by Sacramento River flows. All downstream levee improvements contained in Alternatives 1 and 2 would need to be included to effectively reduce the high frequency flood risk for the study area. Other alternatives offer more efficient methods to reduce the flood risk.	No
5. Maximum Plan	Other plans offer more efficient ways to reduce risk.	No
6. Non-Structural	These measures reduce the consequences of flooding, but do not reduce the probability of flooding and therefore do not significantly reduce the overall risk of flooding.	No

From this Focused Array of alternatives, the most promising alternatives were carried forward into a Final Array of alternatives. Summary descriptions of each alternative in the Final Array are presented below:

- **Alternative 1 – Fix Levees**: Alternative 1 would include the construction of levee remediation measures to address seepage, stability, erosion, and height measures identified for the Sacramento River, Natomas East Main Drainage Canal (NEMDC), Arcade, Dry/Robla, and Magpie Creeks. Alternative 1 would also include erosion measures for specific locations along the American River. Alternative 1 does not include levee raises in the Natomas Basin. (Although the results of the benefits analysis are shown in this document.)

- **Alternative 2 – Sacramento Bypass and Fix Levees:** Alternative 2 would include widening the Sacramento Weir and Bypass to divert more flows into the Yolo Bypass and reduce the need to raise levees along the Sacramento River downstream of the bypass. The levees along the American River, the Natomas East Main Drainage Canal (NEMDC), Arcade, Dry/Robla, and Magpie Creeks, would be improved to address identified seepage, stability, erosion and height concerns through some combination of repairing the levees in place (fix in place) or construction of an adjacent levee with measures to address the concerns. The levees along the Sacramento River would be improved to address identified seepage, stability, and erosion concerns through some combination of repairing the levees in place (fix in place) or construction of an adjacent levee with measures to address the concerns. Alternative 2 would also include erosion measures for specific locations along the American River. Alternative 2 does not include any levee raises in the Natomas Basin. (Although the results of the benefits analysis are shown in this document.)

4.3 WITH-PROJECT RESULTS: RESIDUAL EAD AND BENEFITS BY INDEX POINT AND ALTERNATIVE

The following tables show the without-project EAD and with-project residual EAD results computed in HEC-FDA for each index point/breach/outflanking location. The benefits shown for each alternative in each table are the damages reduced at a respective index point/breach/over flanking location, and represent the benefits to the associated basin if improvements were to occur on the source of flooding where the index point is located and if there were no other sources of flood risk. It should be pointed out that damages and benefits associated with the prevention of emergency cost losses are described and reported in Section 4.6, separately from the other categories, which are reported in Sections 4.3-4.5.

For example, in Table 24, the benefits of Alternative 1 are approximately $25.5 million. All of these benefits could be claimed if improvements to the American River (left bank) were made, and if there were no other sources of flood risk. While the first condition (improvements to the levees) would be met under this scenario, the second condition under this scenario has not yet been met – there is still flood risk from the Sacramento River. Since there is still flood risk from the Sacramento River, the full $25.5 million in benefits cannot be claimed for the entire ARS Basin. (In the next section, the benefits for each basin are estimated by considering all of the sources of flood risk in that basin.)

Tables 24 to 28 show three sets of with-project data. The first set is associated with outputs derived from improvements only to the Sacramento River levees downstream of the confluence with the American River and not from any Sacramento levee raises (Alternative 1) or the Sacramento Bypass widening (Alternative 2). This scenario only applies to the ARS F index point (Table 25), but the columns were added to the other tables for consistency purposes.

Table 24: Without-Project EAD and With-Project Residual EAD (ARS A, left bank American River)

DAMAGE CATEGORY	ARS A INDEX POINT – AMERICAN RIVER SOUTH BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	4,171	N/A	N/A	2,986	1,185	2,966	1,205
Commercial	15,338	N/A	N/A	11,258	4,080	11,136	4,202
Farm	30	N/A	N/A	27	3	27	3
Industrial	3,704	N/A	N/A	3,238	466	3,203	501
Public	11,760	N/A	N/A	8,402	3,358	8,338	3,422
Residential	56,327	N/A	N/A	39,900	16,427	39,664	16,663
TOTAL IP	**91,330**	N/A	N/A	**65,814**	**25,519**	**65,331**	**25,996**

Table 25: Without-Project EAD and With-Project Residual EAD (ARS F, left bank Sacramento River)

DAMAGE CATEGORY	ARS F INDEX POINT – AMERICAN RIVER SOUTH BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	15,080	5,474	9,606	3,084	11,996	2,997	12,083
Commercial	42,514	16,303	26,211	8,403	34,111	8,295	34,219
Farm	395	142	253	79	316	75	320
Industrial	11,197	5,090	6,107	2,051	9,146	2,053	9,144
Public	35,644	13,372	22,272	7,207	28,437	7,091	28,553
Residential	227,555	80,268	147,287	47,213	180,342	45,566	181,989
TOTAL IP	**332,383**	**120,650**	**211,733**	**68,037**	**264,346**	**66,078**	**266,305**

Table 26: Without-Project EAD and With-Project Residual EAD (ARN A, right bank American River)

DAMAGE CATEGORY	ARN A INDEX POINT – AMERICAN RIVER NORTH BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	2,171	N/A	N/A	1,177	994	1,260	911
Commercial	18,967	N/A	N/A	10,316	8,651	11,043	7,924
Farm	0	N/A	N/A	0	0	0	0
Industrial	5,257	N/A	N/A	2,781	2,476	2,982	2,275
Public	4,937	N/A	N/A	2,621	2,316	2,809	2,128
Residential	19,796	N/A	N/A	10,928	8,868	11,699	8,097
TOTAL IP	**51,128**	N/A	N/A	**27,823**	**23,305**	**29,793**	**21,335**

Table 27: Without-Project EAD and With-Project Residual EAD (ARN E, right bank Arcade Creek)

DAMAGE CATEGORY	ARN E INDEX POINT – AMERICAN RIVER NORTH BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	1,050	N/A	N/A	724	326	666	384
Commercial	8,416	N/A	N/A	6,280	2,136	5,866	2,550
Farm	0	N/A	N/A	0	0	0	0
Industrial	4,044	N/A	N/A	2,079	1,965	1,777	2,267
Public	2,023	N/A	N/A	1,646	377	1,523	500
Residential	10,642	N/A	N/A	7,376	3,266	6,735	3,907
TOTAL IP	**26,175**	N/A	N/A	**18,105**	**8,070**	**16,567**	**9,608**

Table 28: Without-Project EAD and With-Project Residual EAD (NAT D, left bank Natomas Cross Canal)

DAMAGE CATEGORY	NAT D INDEX POINT – NATOMAS BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	863	N/A	N/A	382	481	370	493
Commercial	3,294	N/A	N/A	1,511	1,783	1,469	1,825
Farm	36	N/A	N/A	19	17	18	18
Industrial	2,328	N/A	N/A	1,081	1,247	1,051	1,277
Public	2,774	N/A	N/A	1,274	1,500	1,238	1,536
Residential	19,300	N/A	N/A	8,845	10,455	8,595	10,705
TOTAL IP	**28,595**	N/A	N/A	**13,113**	**15,482**	**12,742**	**15,853**

4.4 RANGE OF BENEFITS BY INDEX POINT & ALTERNATIVE

The following tables present ranges of benefits for each alternative and at each index point. HEC-FDA computes damages reduced (benefits) at specific probabilities (25%, 50%, and 75%); the intersection of the probability and the dollar value in the table can be read as, "There is an X chance that damages reduced (benefits) exceeds Y." The benefits in these tables provide a broader picture of the possible range in benefits that may be realized considering all of the hydrologic, hydraulic, geotechnical, and economic uncertainty.

Table 29: Range of Benefits at ARS A (In $1000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	91,330	--	--	--	--	--
Alt. 1 FIP	91,330	65,814	25,519	17,001	21,266	30,223
Alt. 2 SB	91,330	65,331	25,996	16,944	21,166	30,816

Table 30: Range of Benefits at ARS F (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	332,383	--	--	--	--	--
Alt. 1 FIP	332,383	68,037	264,346	148,191	194,802	372,595
Alt. 2 SB	332,383	66,078	266,305	151,059	202,639	378,927

Table 31: Range of Benefits at ARN A (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	51,128	--	--	--	--	--
Alt. 1 FIP	51,128	27,823	23,305	8,459	17,492	34,125
Alt. 2 SB	51,128	29,793	21,335	7,281	15,667	31,414

Table 32: Range of Benefits at ARN E (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	26,175	--	--	--	--	--
Alt. 1 FIP	26,175	18,105	8,070	4,573	7,128	10,783
Alt. 2 SB	26,175	16,567	9,608	4,874	8,102	12,670

Table 33: Range of Benefits at NAT D (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	28,595	--	--	--	--	--
Alt. 1 FIP	28,595	13,113	15,482	10,847	14,297	19,378
Alt. 2 SB	28,595	12,742	15,853	11,106	14,652	19,784

4.5 WITH-PROJECT RESULTS: BENEFITS BY BASIN AND ALTERNATIVE

Tables 34 and 35 below display the benefits of each alternative by basin. The benefit values in these tables reflect improvements made to each source of flood risk within a particular basin. For example, in the ARS Basin, FRM improvements are made to reduce risk from both the American and Sacramento Rivers. These tables reflect benefits that would be realized in a basin (i.e., in a single consequence area) by thinking of the flood problem from a broader system perspective rather than from just individual, discrete sources of flood risk.

Table 34: Average Annual Benefits for Alternative 1 (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

BASIN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	AVERAGE ANNUAL BENEFITS
ARS	332,383 (ARS F)	68,037 (ARS F)	**264,346**
ARN	77,303 (ARN A + ARN E)	45,928 (ARN A + ARN E)	**31,375**
NATOMAS	28,595 (NAT D)	13,113 (NAT D)	**15,482**
TOTAL	438,281	127,078	**311,203**

Table 35: Average Annual Benefits for Alternative 2 (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

BASIN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	AVERAGE ANNUAL BENEFITS
ARS	332,383 (ARS F)	66,078 (ARS F)	**266,305**
ARN	77,303 (ARN A + ARN E)	46,360 (ARN A + ARN E)	**30,943**
NATOMAS	28,595 (NAT D)	12,742 (NAT D)	**15,853**
TOTAL	438,281	125,180	**313,101**

As explained throughout the preceding sections, the benefits of FRM improvements in the study area have been computed using simplifying assumptions and simplified computations in order to make reasonable estimates using available resources, which include time, money, data, as well as software applications. Simplifications were necessary considering that the study area may flood from multiple water sources.

As an example, the method used to compute benefits for the ARS Basin was selected based on information that the American and Sacramento Rivers are moderately correlated in terms of hydrology and hydraulics. While it is believed that the method used (compute risk at multiple index points and use the highest EAD) accurately accounts for damages, residual damages, and benefits associated with the ARS Basin, it also should be noted that this may not be the most rigorous method to estimate benefits for this basin. The most rigorous method to compute benefits given the multiple-source flooding situation in the ARS Basin would be to use a model that fully represents the system and could account for various "what if" scenarios:

- What if there is a levee breach along the American River first? Would this affect the probabilities of flooding along the Sacramento River downstream of the confluence?
- What if there is a breach along the Sacramento River first? Would this affect the probabilities of flooding along the American River?
- What if there is a levee breach along both rivers at the same time?

While a true systems approach is ideal, it may not be practical until more sophisticated analytical tools are developed and tested by FRM practitioners. In the meantime, it is believed that the method used to estimate benefits for this current analysis balances rigor with practicality without sacrificing accuracy.

4.6 BENEFITS ASSOCIATED WITH THE PREVENTION OF EMERGENCY COSTS

Prevention of Emergency Cost Losses: Tables 36-39 display the without-project EAD (repeated from Section 3.3.2) and the with-project benefits achieved under each alternative and for each basin. Both Alternatives 1 and 2 reduce the frequency of flooding to Sacramento and therefore prevent a significant amount of emergency-related costs from being incurred. Under each alternative, EAD would be reduced by about 75%, or to about $16.7 million for Alternative 1 and $17.8 million for Alternative 2. Therefore the annual benefits of Alternative 1 are approximately $48.6 million and those of Alternative 2 are approximately $47.4 million. For either alternative, the prevention of clean-up and TERHA costs comprise about 13% of total benefits for the Sacramento study area.

Separately, the benefits from the prevention of emergency cost losses associated with the Tributaries increment in the ARN Basin are approximately $1.25 million (Alternative 1) and $1.45 million (Alternative 2); the benefits associated with the American River increment are approximately $3.2 million (Alternative 1) and $2.9 million (Alternative 2).

Table 36: Expected Annual Damages and Benefits – Alternative 1, ARCF Clean-Up and TERHA Costs (In $1,000s, October 2015 Price Level)

Category	Without-Project			With-Project (Alternative 1)			Average Annual Benefits
	ARS Basin	ARN Basin	Total	ARS Basin	ARN Basin	Total	
Clean-UP	36,860	7,653	44,513	7,161	4,418	11,579	32,934
TERHA	17,933	2,805	20,738	3,478	1,617	5,095	15,643
Total	**54,793**	**10,458**	**65,251**	**10,639**	**6,035**	**16,674**	**48,577**

Table 37: Expected Annual Damages and Benefits – Alternative 2, ARCF Clean-Up and TERHA Costs (In $1,000s, October 2015 Price Level)

Category	Without-Project			With-Project (Alternative 2)			Average Annual Benefits
	ARS Basin	ARN Basin	Total	ARS Basin	ARN Basin	Total	
Clean-UP	36,860	7,653	44,513	7,873	4,465	12,338	32,175
TERHA	17,933	2,805	20,738	3,839	1,627	5,466	15,272
Total	**54,793**	**10,458**	**65,251**	**11,712**	**6,092**	**17,804**	**47,447**

Table 38: Expected Annual Damages and Benefits – Alternative 1, ARCF Clean-Up and TERHA Costs (In $1,000s, October 2015 Price Level) Separated by American River and Tributaries Increments

Category	Without-Project			With-Project (Alternative 1)			Average Annual Benefits
	American River (ARN Basin)	Tributaries (ARN Basin)	Total	American River (ARN Basin)	Tributaries (ARN Basin)	Total	
Clean-UP	5,088	2,565	7,653	2,738	1,680	4,418	3,235
TERHA	1,805	1,000	2,805	978	639	1,617	1,188
Total	**6,892**	**3,565**	**10,458**	**3,717**	**2,319**	**6,035**	**4,423**

Table 39: Expected Annual Damages and Benefits – Alternative 2, ARCF Clean-Up and TERHA Costs (In $1,000s, October 2015 Price Level) Separated by American River and Tributaries Increments

Category	Without-Project			With-Project (Alternative 2)			Average Annual Benefits
	American River (ARN Basin)	Tributaries (ARN Basin)	Total	American River (ARN Basin)	Tributaries (ARN Basin)	Total	
Clean-UP	5,088	2,565	7,653	2,931	1,534	4,465	3,188
TERHA	1,805	1,000	2,805	1,048	579	1,627	1,178
Total	**6,892**	**3,565**	**10,458**	**3,980**	**2,113**	**6,092**	**4,366**

4.7 NATOMAS BASIN – NO ADDITIONAL IMPROVEMENTS (LEVEE RAISES) RECOMMENDED

The Natomas Basin had largely been an agricultural area until recent times. After having been given assurances that the levees provided adequate flood protection, residential and commercial development increased in this area in the late 1990s and mid 2000s. Subsequent investigations and signs of levee distress during high flows have shown that the area is still at significant risk of flooding. Further flood risk reduction is needed, not only to meet the FEMA regulatory requirements, but also to meet the State of California requirement for 200-year level of protection for urban areas. The Natomas 2010 PAC report includes recommendations for Federal involvement in flood risk reduction through levee improvements which would provide a 1 in 67 annual exceedence probability (a 1 in 67 chance of being exceeded in any given year). These recommendations were authorized by WRRDA 2014. State and local agencies implemented improvements to more than a third of the perimeter levee system in advance of the Federal authorization. Some of those improvements were previously approved for consideration for credit under Section 104 (WRDA 1986). This GRR considered further flood risk reduction features (levee raises) for the Natomas Basin.

Initially assessments of both of the final alternatives included additional flood risk reduction for the Natomas Basin in the form of levee raises. The final alternatives included measures that would attain FEMA level accreditation as well as meet the State of California's requirement for 200 year level of protection for urban areas. The Administration has concerns with USACE projects enabling growth in floodplains. This additional growth would increase the consequences of flooding within the Basin and therefore increase the future flood risk. In fact, a preliminary assessment completed for the 2010 Natomas PACR (2010 Natomas Post-Authorization Change and Interim GRR, Economic Appendix H, Attachment 8) indicated that by the year 2035 there could be an additional 40,000 people and 16,000 structures worth about $6 billion located in the Basin, which would translate into additional flood damages of approximately $3.3 billion from a 1% annual chance exceedance (ACE) event. Discussions with the project partners determined that, in light of ongoing locally-driven regional planning efforts that are investigating regional-scale flood risk reduction measures to deal with large flood events, this ARCF GRR would not make further recommendations for the Natomas Basin. This is because the other local regional planning efforts could recommend implementation of other measures that would render levee raises around the Natomas Basin unnecessary.

Raising levees around the Natomas Basin is a separate element common to both of the action alternatives in the final array. As such, removal of those features from both alternatives does not change the identification of the NED Plan. Therefore, as a final step following plan comparison, the final array of alternatives was reformulated to remove the Natomas levee raise features.

4.8 BENEFITS OUTSIDE THE IMMEDIATE STUDY AREA: CITY OF WEST SACRAMENTO

Widening the Sacramento Bypass (Alternative 2) provides benefits to the city of West Sacramento, which is located on the right bank (west side) of the Sacramento River adjacent to the confluence with the American River and directly across the river from the city of Sacramento. The benefits are achieved through lower flows and stages in the Sacramento River downstream of the Sacramento Bypass, effectively decreasing the computed frequency of flooding from the Sacramento River into the city of West Sacramento and thereby reducing expected annual damages from flooding along the Sacramento River. However, these potential benefits are not effectively realized because the highest damages within the West Sacramento study area are instead driven by flooding coming from the Yolo Bypass, which does not see any decrease in water surface elevation from widening of the Sacramento Bypass.

A General Reevaluation Report (GRR) is currently being completed for the West Sacramento area.

4.9 WITH-PROJECT PERFORMANCE RESULTS: AEP, LONG-TERM RISK, & ASSURANCE

Tables 40 to 42 present the performance statistics under both without-project and with-project conditions for each index point, basin, and alternative.

The AEP values under with-project conditions indicate that each alternative provides significant risk reduction in terms of the chance of flooding in any given year. For example, in the ARS Basin, without-project AEP is about 1 in 32 (1 in 97 for ARS A on American River and 1 in 32 for ARS F on Sacramento River). With improvements made to both risk sources, flood risk is reduced to about a 1 in 135 (Alternative 1) and 1 in 147 (Alternative 2).

The long-term risk statistics indicate that the chance of flooding over a certain time period is also reduced. In the ARS Basin, the chance of flooding over a 10-year and 30-year period improves significantly with a project in place, while in the ARN Basin this improvement isn't as great. Like the ARS Basin, the Natomas Basin would also experience a significant reduction in long-term risk with levee improvements.

Table 40: AEP -- Without-Project and With-Project Conditions

BASIN	INDEX POINT	ANNUAL EXCEEDANCE PROBABILITY (AEP)			
		WITHOUT	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)	ALT. 1 (WITH SAC RAISES)	ALT. 2 SBW
ARS	ARS A	0.0103	0.0051	0.0051	0.0051
	Flanking	0.0033	--	--	--
	ARS F	0.0310	0.0104	0.0074	0.0068
ARN	ARN A	0.0104	0.0055	0.0055	0.0058
	Flanking	0.0009	--	--	--
	ARN E	0.0165	0.0165	0.0050	0.0039

Table 41: Long-Term Risk -- Without-Project and With-Project Conditions

BASIN	INDEX POINT	LONG-TERM RISK							
		WITHOUT		FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALT. 1 (WITH SAC RAISES)		ALT. 2 SBW	
		10 YEARS	30 YEARS	10 YEARS	30 YEARS	10 YEARS	30 YEARS	10 YEARS	30 YEARS
ARS	ARS A	13%	27%	5%	14%	5%	14%	5%	13%
	Flank.	3%	10%	--	--	--	--	--	--
	ARS F	27%	61%	10%	27%	7%	20%	7%	18%
ARN	ARN A	10%	27%	5%	15%	5%	15%	5%	16%
	Flank.	1%	3%	--	--	--	--	--	--
	ARN E	15%	39%	5%	14%	5%	14%	4%	11%

Table 42: Assurance -- Without-Project and With-Project Conditions

BASIN	INDEX POINT	ASSURANCE BY EXCEEDANCE PROBABILITY EVENT											
		WITHOUT			FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)			ALT. 1 (WITH SAC RAISES)			ALT. 2 SBW		
		4%	1%	.2%	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%
ARS	ARS A	93%	77%	18%	98%	91%	31%	98%	91%	31%	98%	91%	32%
	Flank.	99%	84%	6%	--	--	--	--	--	--	--	--	--
	ARS F	75%	69%	24%	95%	94%	36%	95%	95%	89%	95%	95%	81%
ARN	ARN A	92%	75%	22%	99%	90%	24%	99%	90%	24%	98%	89%	22%
	Flank.	99%	98%	40%	--	--	--	--	--	--	--	--	--
	ARN E	90%	68%	7%	99%	94%	23%	99%	94%	23%	99%	95%	28%

4.10 SCREENING-LEVEL COST ESTIMATES: BY ALTERNATIVE, BASIN, & SOURCE OF FLOOD RISK

Preliminary, screening-level cost estimates were provided by the District's Cost Engineering Section. Detailed costs were provided in several formats; the costs broken out by stream/river were used for this economic analysis and are summarized in Tables 43 and 44 below. In addition to project first costs, interest during construction (IDC), which is an economic cost, was also factored into the net benefit/BCR analyses. Information regarding the construction period (number of years) and the construction schedule for each alternative was provided by the Civil Design and used to compute IDC on an annual basis. The construction period for both Alternatives 1 and 2 are estimated to be 10 years; the construction schedules for each alternative identifies the timing of the improvements by reach and by year. The Total Project Cost Summaries (TPCS) for Alternatives 1 and 2 are shown in Attachment 2 and more detailed reach-by-reach cost estimates and schedules can be found in the Cost Engineering Appendix.

Table 43: Alternative 1 -- Costs

BASIN	ALTERNATIVE 1: FIX IN PLACE (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.125% DISCOUNT RATE)						
	RISK SOURCE	FIRST COSTS[1]	IDC[2]	TOTAL COSTS	AVERAGE ANNUAL COSTS (AAC)	O&M	TOTAL AAC
ARS	American	260,439	68,565	329,004	13,092	N/A	13,092
	Sacramento	677,122	127,289	804,411	32,010	N/A	32,010
	Sac Raises	61,088	13,948	75,036	2,986	N/A	2,986
	Total Basin	**998,649**	**209,803**	**1,208,452**	**48,088**	N/A	**48,169**
ARN	American	139,076	22,540	161,616	6,431	N/A	6,431
	Tributaries[3]	198,030	22,379	220,409	8,771	N/A	8,771
	Total Basin	**337,106**	**44,919**	**382,025**	**15,202**	N/A	**15,202**
GRAND TOTAL	**All Basins**	**1,335,755**	**254,722**	**1,590,477**	**63,290**	**286**	**63,576**

[1] Costs associated with cultural resource preservation ($8.237M) excluded from economic analysis as per USACE policy
[2]Interest During Construction
[3]Includes Arcade, Dry, and Robla Creeks and the Natomas East Main Drainage Canal (NEMDC)

Table 44: Alternative 2 -- Costs

BASIN	ALTERNATIVE 2: SACRAMENTO BYPASS WIDENING (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.125% DISCOUNT RATE)						
	RISK SOURCE	FIRST COSTS[1]	IDC[2]	TOTAL COSTS	AVERAGE ANNUAL COSTS (AAC)	O&M	TOTAL AAC
ARS	American	262,447	69,096	331,543	13,193	N/A	13,193
	Sacramento	677,122	127,289	804,411	32,010	N/A	32,010
	Sac Bypass	278,527	67,601	346,128	13,773	N/A	13,773
	Total Basin	**1,218,096**	**263,986**	**1,482,082**	**58,976**	N/A	**58,976**
ARN	American	140,151	22,714	162,865	6,481	N/A	6,481
	Tributaries[3]	199,266	22,530	221,796	8,826	N/A	8,826
	Total Basin	**339,417**	**45,244**	**384,661**	**15,307**	N/A	**15,307**
GRAND TOTAL	**All Basins**	**1,557,513**	**309,230**	**1,866,743**	**74,283**	**494**	**74,777**

[1]Costs associated with cultural resource preservation ($8.237M) excluded from economic analysis as per UACE policy
[2]Interest During Construction
[3]Includes Arcade, Dry, and Robla Creeks and the Natomas East Main Drainage Canal (NEMDC)

4.11 NET BENEFIT AND BENENFIT-TO-COST ANALYSES: PERFORMED INCREMENTALLY BY SOURCE OF FLOOD RISK & BASIN

Incremental net benefit/benefit-to-cost analyses were performed for each basin using the major sources of flood risk within a basin as the incremental unit. The cost information presented in Tables 43 and 44 was used to perform the analyses, which are presented in Tables 45 and 46 for the ARS and ARN Basins, respectively. The incremental analysis includes damages and benefits associated with structures, contents, automobiles, and emergency cost losses.

In the ARS Basin, addressing both sources of risk (in tandem) as part of an overall system is necessary in order to significantly reduce risk to the basin as a whole. Without addressing improvements to both the Sacramento and American Rivers, the ARS Basin, which includes downtown Sacramento and the state government buildings, still faces a significant level of risk in terms of the chance of flooding and consequences of flooding. O&M Costs are not included in the incremental analysis because they are negligible and will not affect the result.

Table 45: Incremental Net Benefit and Benefit-to-Cost Analyses for Alternatives 1 and 2 in ARS Basin (Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis, 3.125% Discount Rate)

Increment	Without-Project EAD/Resid EAD	Increm. Average Annual Benefits (AAB)	Cumulat. AAB	Increm. Average Annual Costs (AAC)	Cumulat. AAC	Increm. Net Benefits	Cumulat. Net Benefits	Increm. Benefit-to-Cost Ratio (BCR)	Cumalat. BCR
Alternative 1: Fix in Place (FIP)									
0 -- No Action	387,175	0	0	0	0	0	0	N/A	N/A
1 -- Fix Sac River	140,076	247,099	247,099	32,010	32,010	215,089	215,089	7.7	7.7
2a – Raise Sac River	105,859	34,217	281,316	2,986	34,996	31,231	246,320	11.5	8.0
2b – Fix American River	78,675	27,184	308,500	13,092	48,088	14,092	260,412	2.1	6.4
Total	N/A	308,500	308,500	48,088	48,088	260,412	260,412	6.4	6.4
Alternative 2: Sacramento Bypass Widening (SBW)									
0 -- No Action	387,175	0	0	0	0	0	0	N/A	N/A
1 -- Fix Sac River	140,076	247,099	247,099	32,010	32,010	215,089	215,089	7.7	7.7
2a – Widen Sac Bypass	105,859	34,217	281,316	13,773	45,783	20,444	235,533	2.5	6.1
2b – Fix American River	77,790	28,070	309,386	13,193	58,976	14,877	250,410	2.1	5.2
Total	N/A	309,386	309,386	58,976	58,976	250,410	250,410	5.2	5.2

Walking through the incremental analysis, Table 45 shows the first increment, under both alternatives, as being improving the Sacramento River levees (but no levee raises under Alternative 1 and no widening of the Sacramento Bypass under Alternative 2). Following improvements to the Sacramento River (fix levees under both Alternatives 1 and 2) the next logical step according to the results of the HEC-FDA analysis would be to address either the raise on the Sacramento River or the widening of the Sacramento Bypass, where AEP and residual damages are the next highest. Once these improvements are made, the American River levees would be improved.

It should be pointed out that this planning-level economic analysis indicates that improvements to the American River would be completed after (or in tandem with) either the Sacramento River levee raises (Alt 1) or Sacramento Bypass widening (Alt 2) in order for the ARS Basin to realize its full benefits from either the levee raises or bypass widening.

Table 46: Incremental Net Benefit and Benefit-to-Cost Analyses for Alternatives 1 and 2 in ARN Basin (Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis, 3.125% Discount Rate)

Increment	Without-Project EAD/Resid EAD	Increm. Average Annual Benefits (AAB)	Cumulat. AAB	Increm. Average Annual Costs (AAC)	Cumulat. AAC	Increm. Net Benefits	Cumulat. Net Benefits	Increm. Benefit-to-Cost Ratio (BCR)	Cumalat. BCR
Alternative 1: Fix in Place (FIP)									
0 -- No Action	87,762	0	0	0	0	0	0	N/A	N/A
1 -- Fix American	61,280	26,482	26,482	6,431	6,431	20,051	20,051	4.1	4.1
2 -- Fix Creeks	51,964	9,316	35,798	8,771	15,202	545	20,596	1.1	2.4
Total	N/A	35,798	35,798	15,202	15,202	20,596	20,596	2.4	2.4
Alternative 2: Sacramento Bypass Widening (SBW)									
0 -- No Action	87,762	0	0	0	0	0	0	N/A	N/A
1 -- Fix American	63,513	24,249	24,249	6,481	6,481	17,768	17,768	3.7	3.7
2 -- Fix Creeks	52,453	11,060	35,309	8,826	15,307	2,234	20,002	1.3	2.3
Total	N/A	35,309	35,309	15,307	15,307	20,002	20,002	2.3	2.3

One point of interest is the Creeks increment in the ARN Basin. While Table 46 indicates that this increment is only marginally justified (i.e., it has a BCR of 1.1 for Alt 1), the proposed improvements help to significantly reduce the residual risk to a basin where risk to human life is high.

Additionally, the increment is further justified in the Federal Interest with a social justice argument. The area receiving benefit from the Creeks increment represents one of the most impoverished locations in Sacramento County.[4] In fact, the median family income in Sacramento is more than 50 percent higher than the median family income of the affected area ($55,064 compared to $35,828); the poverty rate in the affected area is 64 percent higher that of the surrounding county (29.0% compared to 17.6%). Within some parts of the affected area more than one in three family's live below the poverty line (34.1% in zip code 95815). Furthermore, these high rates of poverty are strongly correlated with disabilities, lack of car ownership and other factors that increase life safety hazards. In the absence of this justified increment, the flood risks for this area would change very little, thereby putting this community at a further disadvantage relative to neighboring communities in the study area.

Net benefit/benefit-to-cost analyses for Alternative 1 and Alternative 2 are summarized in Tables 47 and 48 below. The calculations were performed using the information from the previous tables.

[4] The above analysis is based on the US Census Bureau 2009-2013 American Community Survey comparing Sacramento County to the zip codes most closely associated with the area affected by the increment (95815 and 95838).

Table 47: Final Net Benefits and Benefit-to-Cost Ratio – Alternative 1 (Dollar Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis, 3.125% Discount Rate)

Alternative 1	
Without-Project Damages and With-Project Benefits	
Without-Project Expected Annual Damages (EAD)	
ARS Basin – Structures/Contents/Autos	332,383
ARS Basin – Emergency Costs	54,793
ARN Basin – Structures/Contents/Autos	77,303
ARN Basin – Emergency Costs	10,458
Total	**474,937**
With-Project Residual EAD	
ARS Basin – Structures/Contents/Autos	68,037
ARS Basin – Emergency Costs	10,639
ARN Basin – Structures/Contents/Autos	45,928
ARN Basin – Emergency Costs	6,035
Total	**130,639**
Average Annual Benefits (AAB)	
ARS Basin – Structures/Contents/Autos	264,346
ARS Basin – Emergency Costs	44,154
ARN Basin – Structures/Contents/Autos	31,375
ARN Basin – Emergency Costs	4,423
Total AAB	**344,298**
Costs	
Total First Costs[1]	1,335,755
Interest During Construction (IDC)	254,722
Total Costs	1,590,477
Average Annual Costs (AAC)	63,290
O&M Costs	286
Total AAC	**63,576**
Net Benefit and BCR Analyses	
Net Benefits	**280,722**
Benefit-to-Cost Ratio (BCR)	**5.4**

[1] Costs associated with cultural resource preservation ($8.237M) excluded from economic analysis as per USACE policy

Table 48: Final Net Benefits and Benefit-to-Cost Ratio – Alternative 2 (Dollar Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis, 3.125% Discount Rate)

Alternative 2	
Without-Project Damages and With-Project Benefits	
Without-Project Expected Annual Damages (EAD)	
ARS Basin – Structures/Contents/Autos	332,383
ARS Basin – Emergency Costs	54,793
ARN Basin – Structures/Contents/Autos	77,303
ARN Basin – Emergency Costs	10,458
Total	**474,937**
With-Project Residual EAD	
ARS Basin – Structures/Contents/Autos	66,078
ARS Basin – Emergency Costs	11,712
ARN Basin – Structures/Contents/Autos	46,360
ARN Basin – Emergency Costs	6,092
Total	**130,242**
Average Annual Benefits (AAB)	
ARS Basin – Structures/Contents/Autos	266,305
ARS Basin – Emergency Costs	43,081
ARN Basin – Structures/Contents/Autos	30,943
ARN Basin – Emergency Costs	4,366
Total AAB	**344,695**
Costs	
Total First Costs[1]	1,557,513
Interest During Construction (IDC)	309,230
Total Costs	1,866,743
Average Annual Costs (AAC)	74,283
O&M Costs	494
Total AAC	**74,777**
Net Benefit and BCR Analyses	
Net Benefits	**269,918**
Benefit-to-Cost Ratio (BCR)	**4.6**

[1]Costs associated with cultural resource preservation ($8.237M) excluded from economic analysis as per USACE policy

4.12 NED OPTIMIZATION – LEVEE RAISES FOR ALTERNATIVE 1

Two alternative levee heights were evaluated to verify that the NED levee scale was properly identified.

The HEC-FDA model was used to assess a lower levee raise on the Sacramento River in the American River South (ARS) basin and to see how a lower raise would affect the benefits for Alternative 1. Currently, Alternative 1 includes raising levees in order to contain the 200-year water surface elevation (WSEL) plus 3 feet, which is equivalent to about a 1.8-foot levee height increase at the index point location (ARS F) used to model the levee raise. The analysis assessed a lower, 0.9-foot levee raise, or about one-half the height of Alternative 1's 1.8-foot raise (equivalent). The results of the analysis indicate that a lower levee raise would result in about a $21 million reduction in benefits, far outweighing the potential reduction in costs (which could not be more than about a $3.7 million reduction, in average annual terms, since this is the estimate for the current levee raise), indicating that net benefits are lower for a 0.9-foot levee raise than for the current 1.8-foot levee raise (equivalent). Additionally, higher levee raises (i.e., higher than the 200-year plus 3 feet WSEL, at ARS F) on the Sacramento River in the ARS basin (e.g., raises to contain the 0.2% ACE event) would not make sense since any incremental benefit would likely be off-set by damages caused from flooding (outflanking) from the upstream, non-leveed reaches of the American River.

4.13 IDENTIFICATION OF NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

Based on the analysis presented above, both Alternative 1 and Alternative 2 provide positive net benefits. While the benefits for each alternative are very similar and are essentially equal from a risk and uncertainty perspective, it is clear that Alternative 1 would be considered the NED Plan given that it costs approximately $222 million less (first costs) than Alternative 2.

American River Common Features GRR
Attachments to Economic Appendix

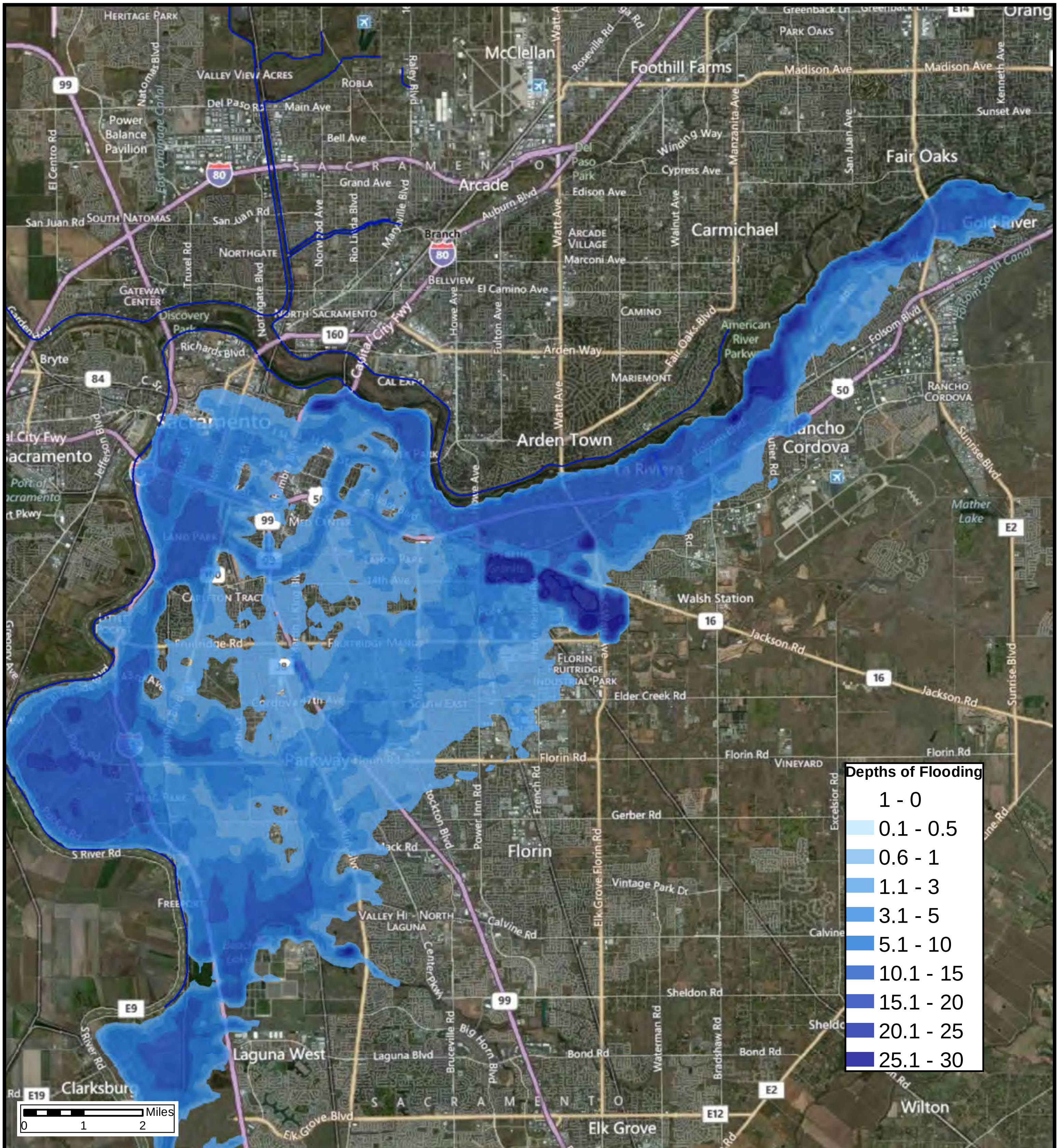
Attachment 1 - Supporting Data (Floodplain Plates, HEC-FDA Input Data)

Attachment 2 – Certified Cost Estimates

Attachment 3 - Other Social Effects (OSE) & Regional Economic Development (RED) Analyses

American River Common Features GRR
Attachments to Economic Appendix

Attachment 1 - Supporting Data (Floodplain Plates, HEC-FDA Input Data)



Legend

ARCF Levees

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

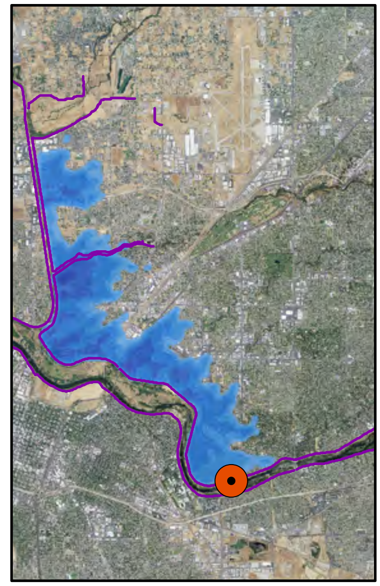
Residual Flooding From Channel Outflanking Into The American River South Basin

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

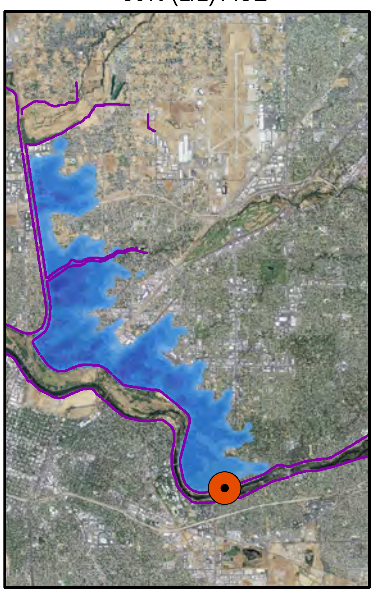
Jan 2013

50% (1/2) ACE

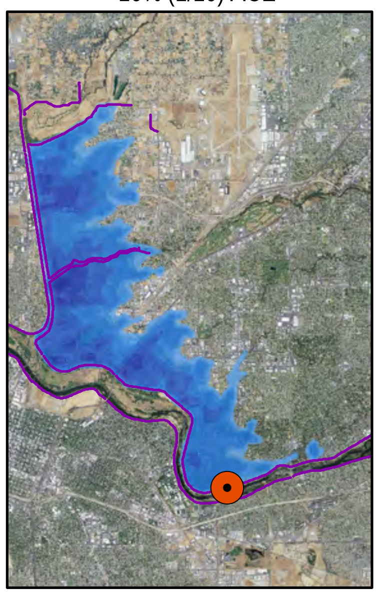
10% (1/10) ACE



4% (1/25) ACE

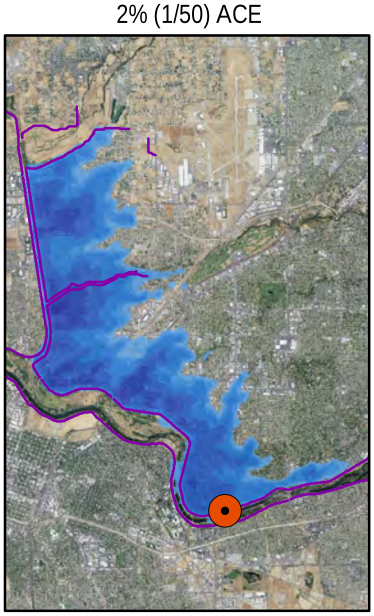


2% (1/50) ACE



1% (1/100) ACE

0.5% (1/200) ACE

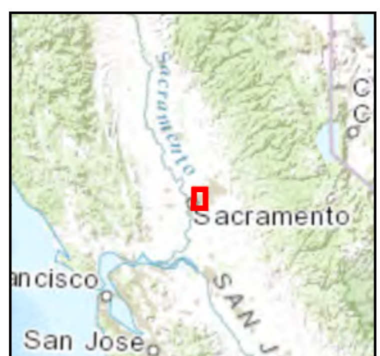


0.2% (1/500) ACE

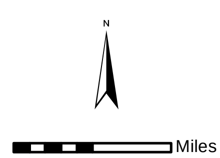
Legend

Depths of Flooding (Feet)

- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 - 30



STUDY AREA EXTENT

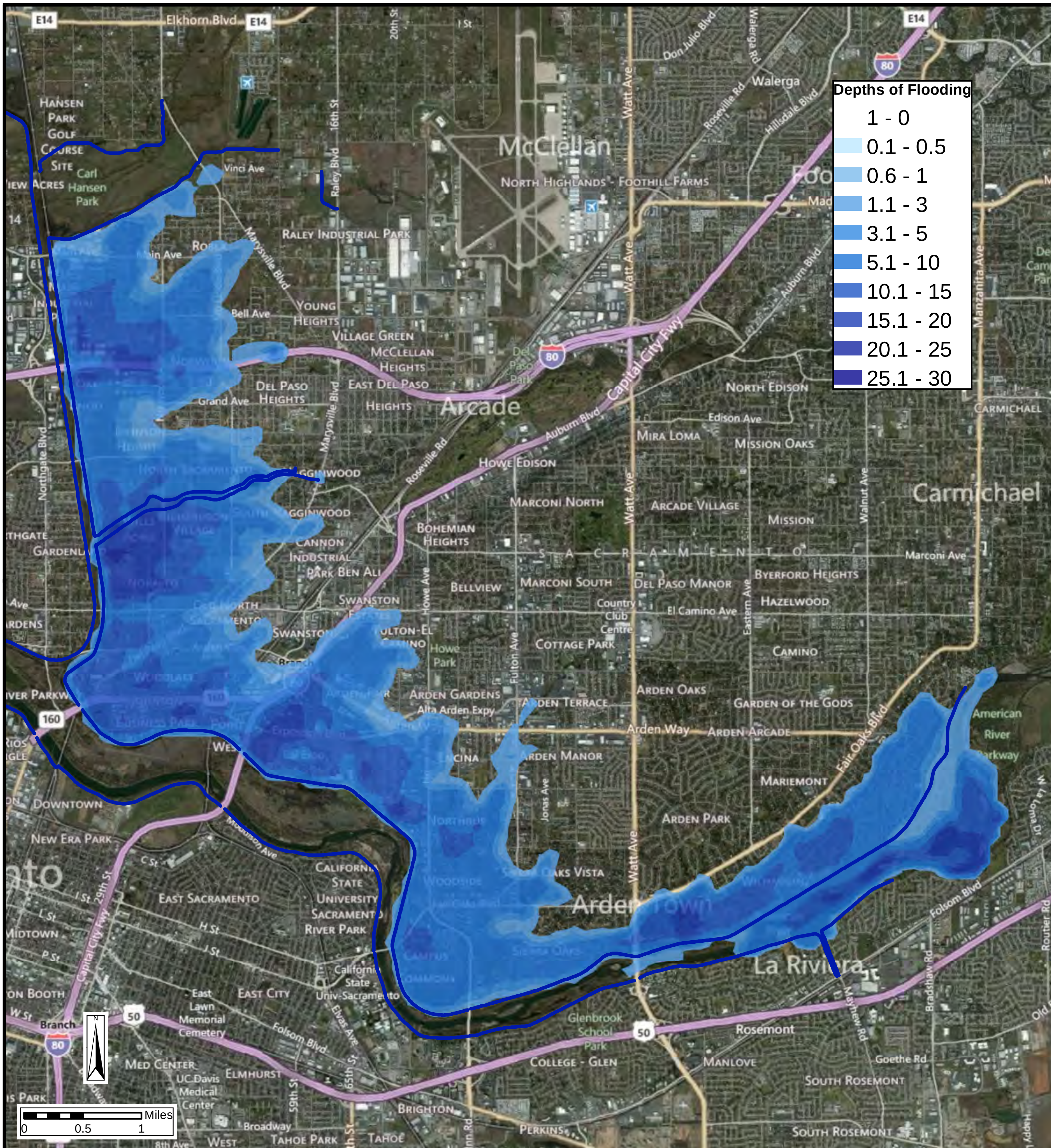


AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Economic Floodplains Based on a Levee Breach Simulation American River North Index Pt A.

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 2013



Legend

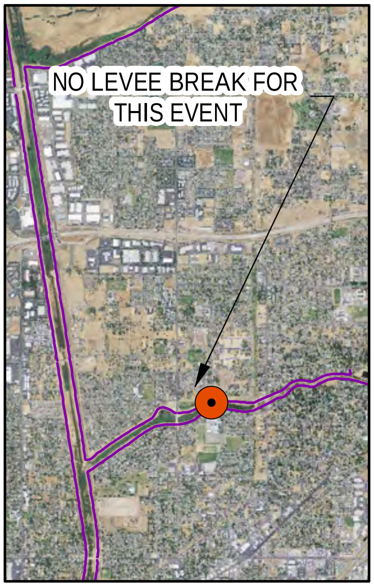
ARCF Levees

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

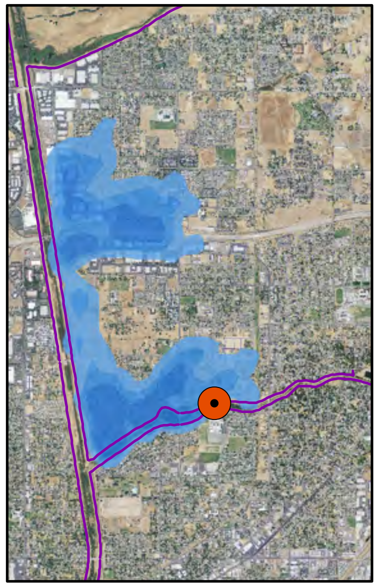
Residual Flooding From Upstream Channel Outflanking Into The American River Basin

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 2013

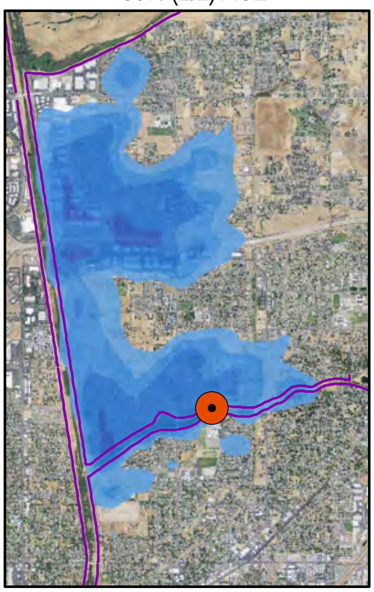


50% (1/2) ACE

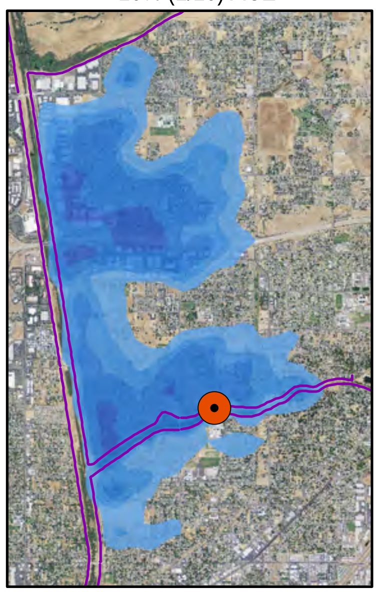


10% (1/10) ACE

10% (1/25) ACE

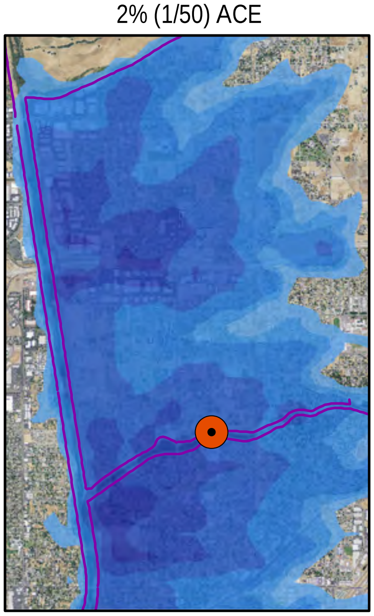


2% (1/50) ACE



1% (1/100) ACE

0.5% (1/200) ACE



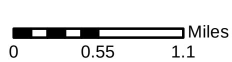
0.2% (1/500) ACE

Legend

Depths of Flooding (Feet)

- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 - 30

STUDY AREA EXTENT



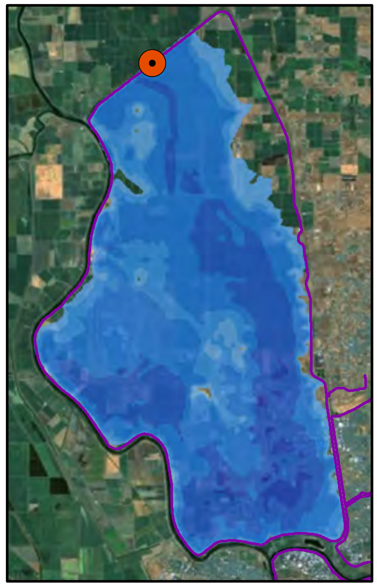
AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Economic Floodplains Based on a Levee Breach Simulation American River North Index Pt E.

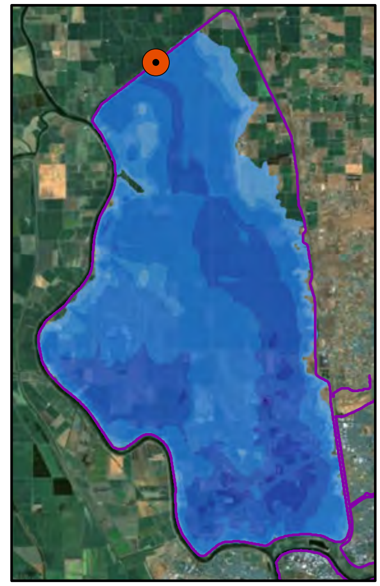
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 2013

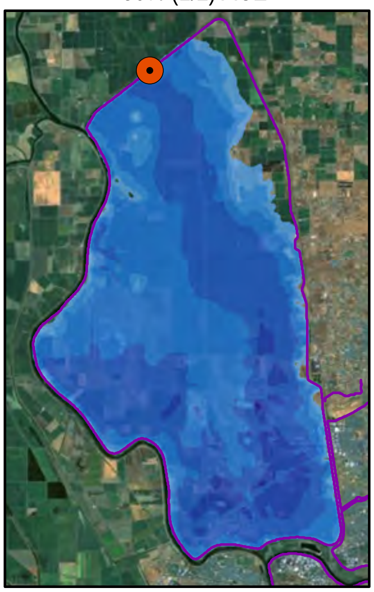
50% (1/2) ACE



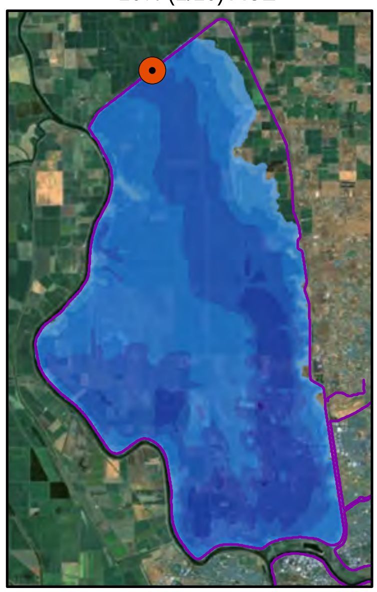
10% (1/10) ACE



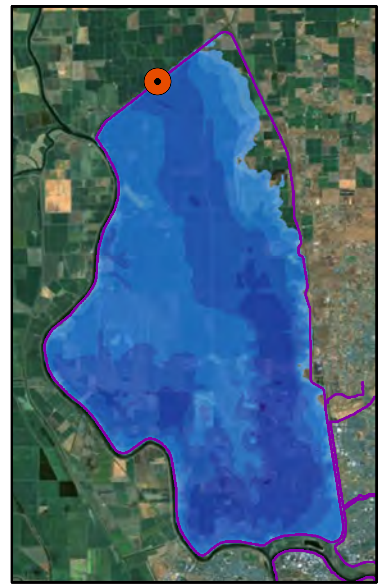
4% (1/25) ACE



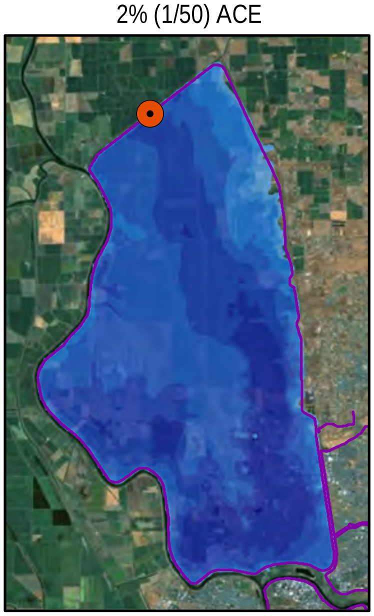
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE

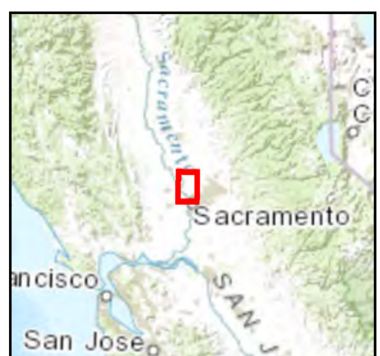


0.2% (1/500) ACE

Legend

Depths of Flooding (Feet)

- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 - 30



STUDY AREA EXTENT

N

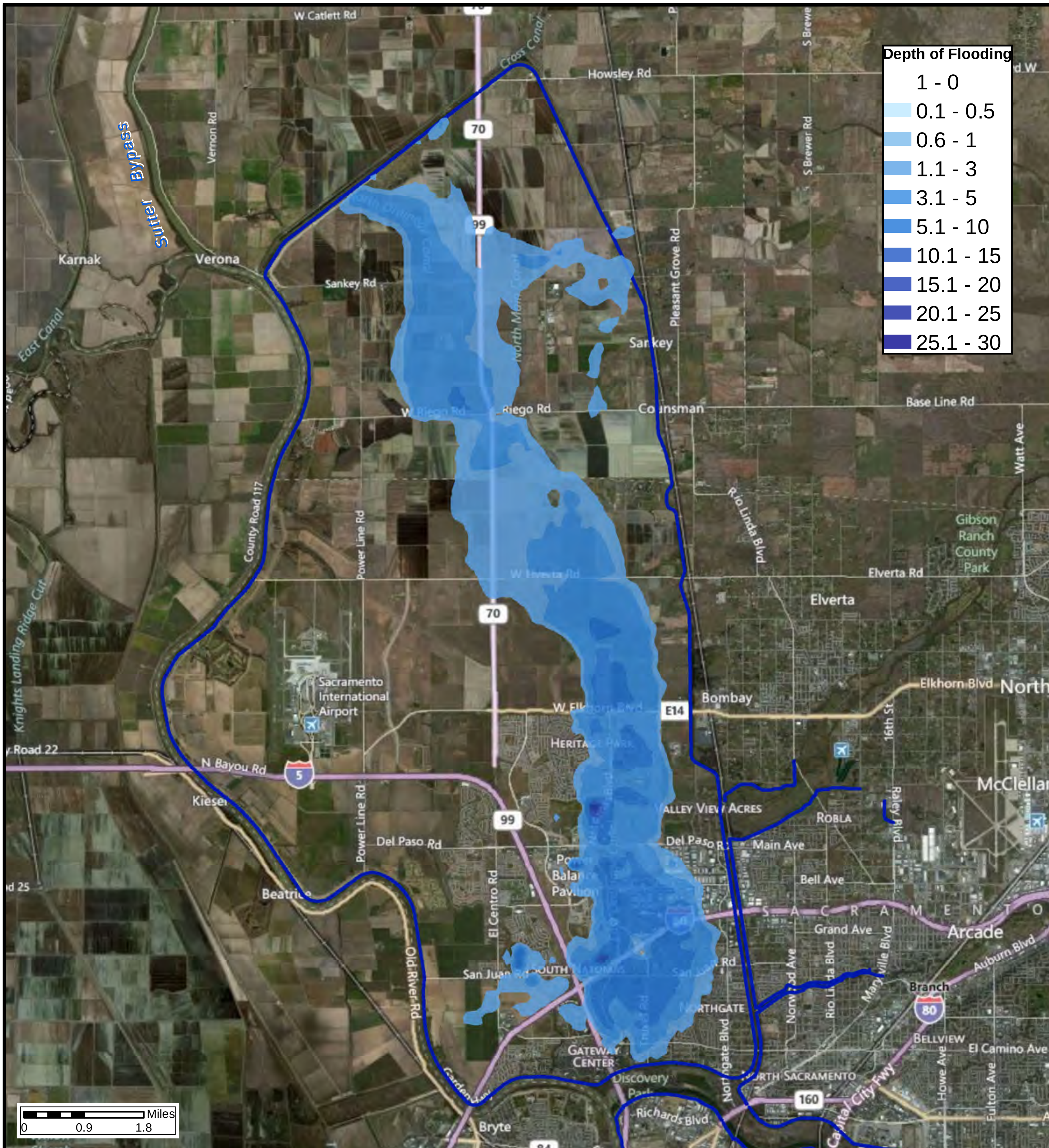
0 2.5 5 Miles

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Economic Floodplains Based on a Levee Breach Simulation Natomas Basin Index Pt D.

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 2013



Legend

ARCF Levees

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Residual Flooding From Sankey Gap Into The Natomas Basin

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 2013

ACF_JFP_RAISE

ARS

ARS_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1423	24.05
2yr = .5	25977	31.85
10yr = .1	71654	41.98
25yr = .04	114993	48.01
50yr = .02	115000	48.07
100yr = .01	114999	48.15
200yr = .005	159995	53.22
500yr = .002	254357	58.1

ARS_F

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	52823	11.05
2yr = .5	94600	20.75
10yr = .1	100687	26.42
25yr = .04	115395	29.04
50yr = .02	118141	29.63
100yr = .01	121788	30.3
200yr = .005	133200	32.03
500yr = .002	152523	33.87

ARN

ARN_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1690	23.25
2yr = .5	25968	31.05
10yr = .1	71653	40.47
25yr = .04	114992	46.57
50yr = .02	114999	46.65
100yr = .01	115000	46.74
200yr = .005	144996	49.96
500yr = .002	243028	56.28

ARN_E

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	26.92
2yr = .5	-	30.02
10yr = .1	-	33.02
25yr = .04	-	35.37
50yr = .02	-	37.77
100yr = .01	-	39.15
200yr = .005	-	41.46
500yr = .002	-	46.22

NAT

NAT_D

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	20.62
2yr = .5	-	33.62
10yr = .1	-	39
25yr = .04	-	41.53
50yr = .02	-	42.43
100yr = .01	-	43.49
200yr = .005	-	44.58
500yr = .002	-	45.2

~~ARS~~

~~ARS_B~~

~~Frequency~~	~~Flow (cfs)~~	~~Stage (ft)~~
~~1yr = .999~~	~~1423~~	~~20.81~~
~~2yr = .5~~	~~25916~~	~~28.61~~
~~10yr = .1~~	~~71643~~	~~33.34~~
~~25yr = .04~~	~~114968~~	~~37.42~~
~~50yr = .02~~	~~114993~~	~~37.74~~
~~100yr = .01~~	~~114999~~	~~38.14~~
~~200yr = .005~~	~~144997~~	~~40.45~~
~~500yr = .002~~	~~195807~~	~~44.79~~

~~ARS_E~~

~~Frequency~~	~~Flow (cfs)~~	~~Stage (ft)~~
~~1yr = .999~~	~~52823~~	~~10.25~~
~~2yr = .5~~	~~94629~~	~~22.55~~
~~10yr = .1~~	~~100691~~	~~28.52~~
~~25yr = .04~~	~~115549~~	~~31.21~~
~~50yr = .02~~	~~118171~~	~~31.79~~
~~100yr = .01~~	~~121790~~	~~32.46~~
~~200yr = .005~~	~~130638~~	~~33.89~~
~~500yr = .002~~	~~148615~~	~~35.79~~

Fix In Place Alternative

ARS

ARS_A

Frequency	Flow (cfs)	Stage (ft)	
1yr = .999	1423	24.05	
2yr = .5	25977	31.85	1.00
10yr = .1	71654	41.98	1.29
25yr = .04	114993	48.01	1.45
50yr = .02	115000	48.07	1.45
100yr = .01	114999	48.15	1.43
200yr = .005	159995	53.22	1.59
500yr = .002	254357	58.1	0.75

ARS_F

Frequency	Flow (cfs)	Stage (ft)	
1yr = .999	52823	11.05	
2yr = .5	94600	20.75	0.75
10yr = .1	100687	26.42	0.77
25yr = .04	115395	29.04	0.76
50yr = .02	118141	29.63	0.76
100yr = .01	121788	30.3	0.76
200yr = .005	133200	32.03	0.75
500yr = .002	152523	33.87	0.78

ARN

ARN_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1690	23.25
2yr = .5	25969	32.43
10yr = .1	71653	40.47
25yr = .04	114991	46.16
50yr = .02	114999	46.24
100yr = .01	115000	46.34
200yr = .005	159998	51.2
500yr = .002	220684	55.91

ARN_E

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	26.98
2yr = .5	-	30.02
10yr = .1	-	33.1
25yr = .04	-	35.37
50yr = .02	-	37.73
100yr = .01	-	39.19
200yr = .005	-	41.41
500yr = .002	-	46.13

NAT

NAT_D

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	20.62
2yr = .5	-	33.62
10yr = .1	-	39
25yr = .04	-	41.53
50yr = .02	-	42.43
100yr = .01	-	43.49
200yr = .005	-	44.58
500yr = .002	-	45.52

~~ARS~~

~~ARS_B~~

~~Frequency~~	~~Flow (cfs)~~	~~Stage (ft)~~
~~1yr = .999~~	~~1423~~	~~20.81~~
~~2yr = .5~~	~~25917~~	~~29.99~~
~~10yr = .1~~	~~71642~~	~~33.34~~
~~25yr = .04~~	~~114967~~	~~37.42~~
~~50yr = .02~~	~~114994~~	~~37.74~~
~~100yr = .01~~	~~114999~~	~~38.15~~
~~200yr = .005~~	~~159970~~	~~41.35~~
~~500yr = .002~~	~~177027~~	~~47.81~~

~~ARS_E~~

~~Frequency~~	~~Flow (cfs)~~	~~Stage (ft)~~
~~1yr = .999~~	~~52823~~	~~10.25~~
~~2yr = .5~~	~~94602~~	~~27.22~~
~~10yr = .1~~	~~100690~~	~~28.52~~
~~25yr = .04~~	~~115558~~	~~31.21~~
~~50yr = .02~~	~~118168~~	~~31.78~~
~~100yr = .01~~	~~121789~~	~~32.46~~
~~200yr = .005~~	~~133311~~	~~34.26~~
~~500yr = .002~~	~~161306~~	~~36.6~~

Sacramento Bypass Widening (1500ft) Alternative

ARS

ARS_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1439	24.05
2yr = .5	25998	31.85
10yr = .1	71655	41.78
25yr = .04	114990	47.88
50yr = .02	114999	47.94
100yr = .01	114999	48.02
200yr = .005	159982	53.04
500yr = .002	254410	58.1

ARS_F

Frequency	Flow (cfs)	Stage (ft)	
1yr = .999	47842	11.05	
2yr = .5	87375	20.75	0.75
10yr = .1	99631	25.97	0.77
25yr = .04	107204	27.86	0.76
50yr = .02	110188	28.52	0.76
100yr = .01	113973	29.33	0.76
200yr = .005	124750	30.93	0.75
500yr = .002	144263	33.36	0.78

ARN

ARN_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1631	22.66
2yr = .5	25996	30.46
10yr = .1	71654	40.56
25yr = .04	114987	46.42
50yr = .02	114999	46.5
100yr = .01	114999	46.59
200yr = .005	159979	51.41
500yr = .002	215253	55.66

ARN_E

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	26.58
2yr = .5	-	29.35
10yr = .1	-	33.22
25yr = .04	-	34.75
50yr = .02	-	36.11
100yr = .01	-	38.63
200yr = .005	-	40.89
500yr = .002	-	45.22

NAT

NAT_D

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	20.46
2yr = .5	-	33.46
10yr = .1	-	38.86
25yr = .04	-	41.43
50yr = .02	-	42.34
100yr = .01	-	43.42
200yr = .005	-	44.55
500yr = .002	-	45.51

ARS

ARS_B

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1439	19.55
2yr = .5	25992	27.35
10yr = .1	64302	32.7
25yr = .04	114928	36.72
50yr = .02	114992	37.07
100yr = .01	114995	37.5
200yr = .005	159901	40.71
500yr = .002	182206	46.79

ARS_E

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	47842	8.95
2yr = .5	87474	21.25
10yr = .1	100097	28.11
25yr = .04	107546	29.95
50yr = .02	110443	30.61
100yr = .01	114819	31.42
200yr = .005	124876	33.08
500yr = .002	146686	35.75

Basin	ARS
Reach	A
RM	9.08

Without Project

Crest Elev	56.05
L/S Toe Ele	46.75
W/S Toe El	45.93

WSE	Pr(f)
46.75	0
49.75	0.1531
51.4	0.2976
53.05	0.4562
56.05	0.6496

With Project
Alt 1

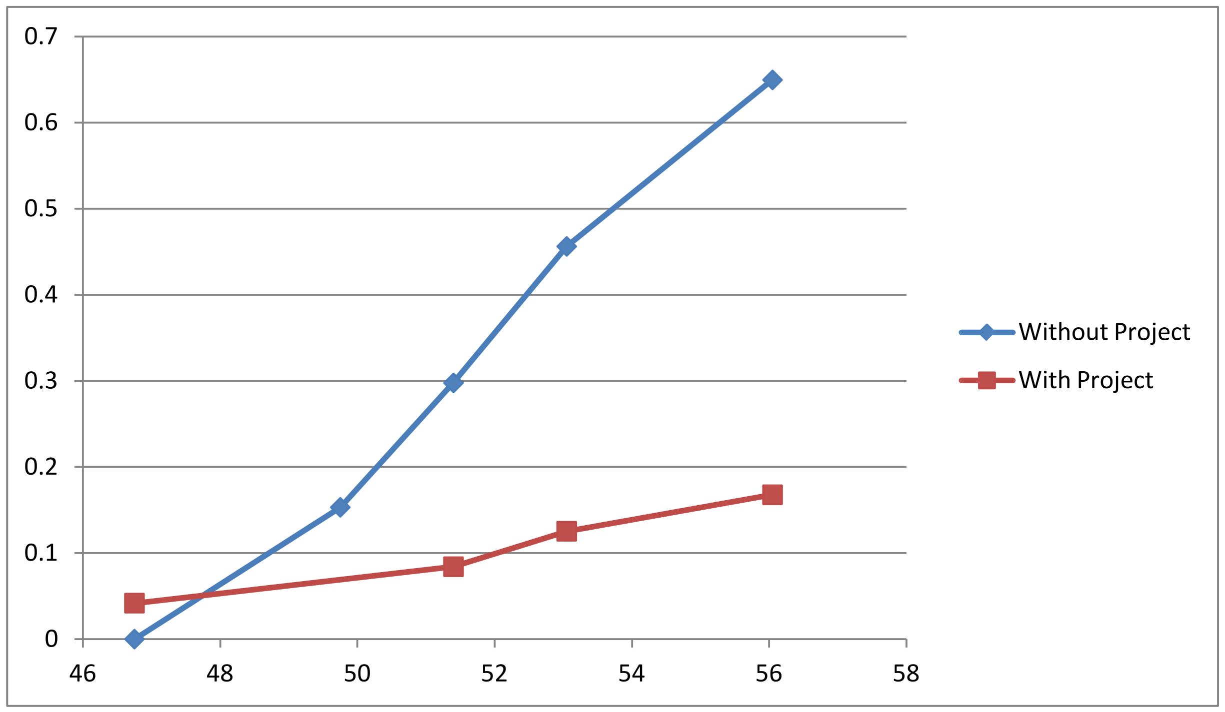
Crest Elev	56.05
L/S Toe Elev	46.75
W/S Toe Elev	45.93

	WSE	Pr(f)	
46.75			0
49.75	46.75	0.0418	0.0418
	51.4	0.0841	
	53.05	0.1253	
	56.05	0.1677	

With Project
Alt 2

Crest Elev	56.05
L/S Toe Elev	46.75
W/S Toe Elev	45.93

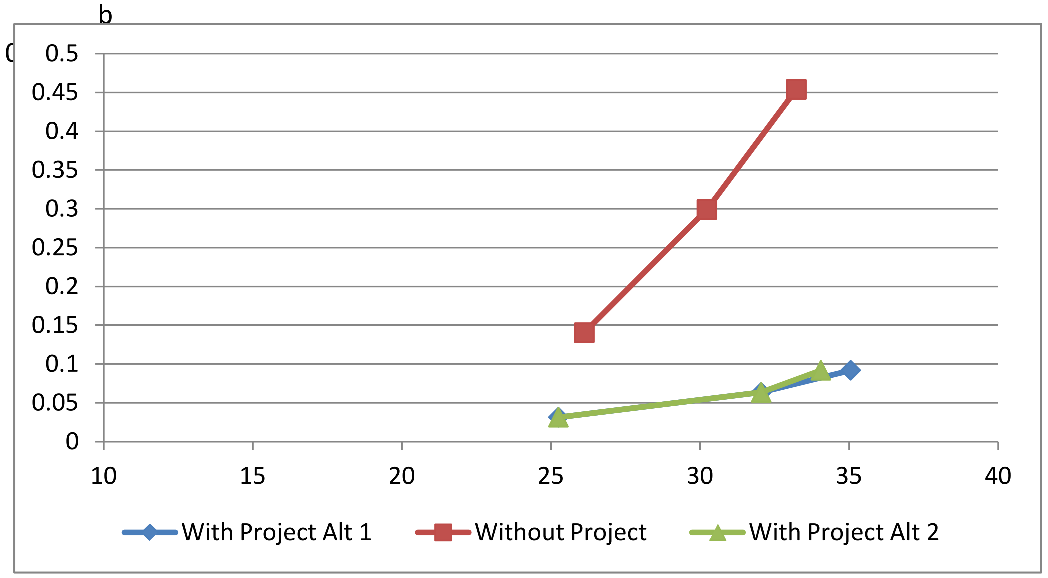
WSE	Pr(f)
46.75	0
49.75	0.0418
51.4	0.0841
53.05	0.1253
56.05	0.1677



1423	20.81	0
25977	33.23	0.83
71654	41.98	0.9
114967	48.01	1.01
114994	48.07	1
114999	48.15	0.95
159970	53.55	0.83
254357	58.1	0.75

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1423	24.05
2yr = .5	25977	31.85
10yr = .1	71654	41.98
25yr = .04	114993	48.01
50yr = .02	115000	48.07
100yr = .01	114999	48.15
200yr = .005	159995	53.22
500yr = .002	254357	58.1

Basin	ARS												
Reach	F												
RM	50.21												
	Without Project				With Project		Testing Values		With Project				
					Alt 1				Alt 2				
	Crest Elev	33.23			Crest Elev	35.05			Crest Elev	34.05		1.82	0.82
	L/S Toe Ele	19			L/S Toe Elev	15.45			L/S Toe Elev	15.45		Removes a 1 foot levee increase....	
	W/S Toe El	22			W/S Toe Elev	21.05			W/S Toe Elev	21.05			
	WSE	Pr(f)			WSE	Pr(f)			WSE	Pr(f)			
	19		0	15.45			0	15.45			0		
	22		0.0572	18.45	22		0.0107	18.45	22		0.0107		
	26.12	0.1403		25.25	25.25	0.0313			25.25	0.0313			
	30.23	0.2991		32.05	32.05	0.0633	0.1266		32.05	0.0633			
	33.23	0.4539		35.05	35.05	0.0918	0.1836		34.05	0.0918	0.0823	Confirm Interpolation with Geotech!	
									35.05	0.0918			
									m	b			
2SACNA3_RL		20.44	94600.12	22.55	94629.31			20.44					
010SACN3_RL		26.41	100687.1	28.52	100690.5	2.11		25.41					
025SACN3_RL		29.03	115394.1	31.21	115549	2.18		28.03					
050SACN3_RL		29.62	118141.1	31.79	118171	2.17		28.62					
100YR_SAC_RL		30.29	121788.3	32.46	121790	2.17		29.29					
200YR_SAC_RL		32.02	133199.8	33.89	130637.5	1.87		31.02					
500YR_SAC_RL		33.86	152522.8	35.79	148615.2	1.93		32.86					



52823	11.05
94600	20.75
100687	26.42
115395	29.04
118141	29.63
121788	30.3
133200	32.03
152523	33.87

Inflow-Outflow from Folsom

NA3 160

	1 in X chance	Inflow	Base Outflow	Min Outflow	Max Outflow
1	1.01569	5,000	2,000	2,000	4,242
2	1.2977	20,002	16,328	2,000	16,967
3	1.4393	25,004	20,411	2,000	21,210
4	1.5655	29,000	24,600	2,000	23,588
5	1.8517	37,002	26,005	2,000	27,464
6	2	40,722	25,215	8,916	30,225
7	5	90,369	44,261	50,000	54,221
8	10	136,522	71,655	65,753	81,913
9	15	167,533	115,000	84,559	115,000
10	20	191,482	115,000	115,000	115,000
11	25	211,227	115,000	115,000	115,000
12	35	243,016	115,000	115,000	115,000
13	50	279,485	115,000	115,000	115,000
14	65	308,218	115,000	115,000	115,000
15	80	332,148	115,000	115,000	115,000
16	100	359,078	115,000	115,000	115,000
17	130	392,399	160,000	115,000	160,000
18	150	411,351	160,000	160,000	160,000
19	175	432,395	160,000	160,000	160,000
20	200	451,163	160,000	160,000	160,000
21	225	468,139	160,000	160,000	172,840
22	250	483,665	193,667	160,000	202,925
23	325	523,757	297,943	214,967	320,734
24	400	556,967	405,477	310,772	430,723
25	500	594,159	534,386	420,080	558,062

Converted Outflow to indexpoint location.

Frequency	1 in X chance per year	Inflow (cfs)	Outflow (cfs)	Min Outflow (cfs)	Max Outflow (cfs)	
1yr = .999	1.01569	5,000	1,423	1,000	4,242	
	1.2977	20,002	16,328	2,000	16,967	
	1.4393	25,004	20,411	2,000	21,210	
	1.5655	29,000	23,588	2,000	24,600	
	1.8517	37,002	26,005	2,000	27,464	
2yr = .5	2	40,722	25,977	8,916	30,225	
	5	90,369	44,261	40,000	54,221	
10yr = .1	10	136,522	71,654	65,753	81,913	
	15	167,533	115,000	84,559	115,000	
	20	191,482	115,000	115,000	115,000	
25yr = .04	25	211,227	114,993	115,000	115,000	
	35	243,016	115,000	115,000	115,000	
50yr = .02	50	279,485	115,000	115,000	115,000	
	65	308,218	115,000	115,000	115,000	
	80	332,148	115,000	115,000	115,000	
100yr = .01	100	359,078	115,000	115,000	115,000	
	130	392,399	159,990	115,000	160,000	
	150	411,351	160,000	160,000	160,000	
	175	432,395	160,000	160,000	160,000	
200yr = .005	200	451,163	160,000	152,705	167,295	
	225	468,139	160,000	160,000	172,840	
	250	483,665	189,459	160,000	202,925	62,223
	325	523,757	212,401	193,667	223,666	20,741.07
	400	556,967	230,558	193,667	244,407	
500yr = .002	500	594,159	254,357	193,667	265,148	

160,000
180,000
215,000
235,000

0.999	1yr = .999	5000	1,423
0.5	2yr = .5	40722	25,977
0.1	10yr = .1	136522	71,654
0.04	25yr = .04	211227	114,993
0	50yr = .02	279485	115,000
0.01	100yr = .01	359078	115,000
0.005	200yr = .005	451163	160,000
0.002	500yr = .002	594159	254,357

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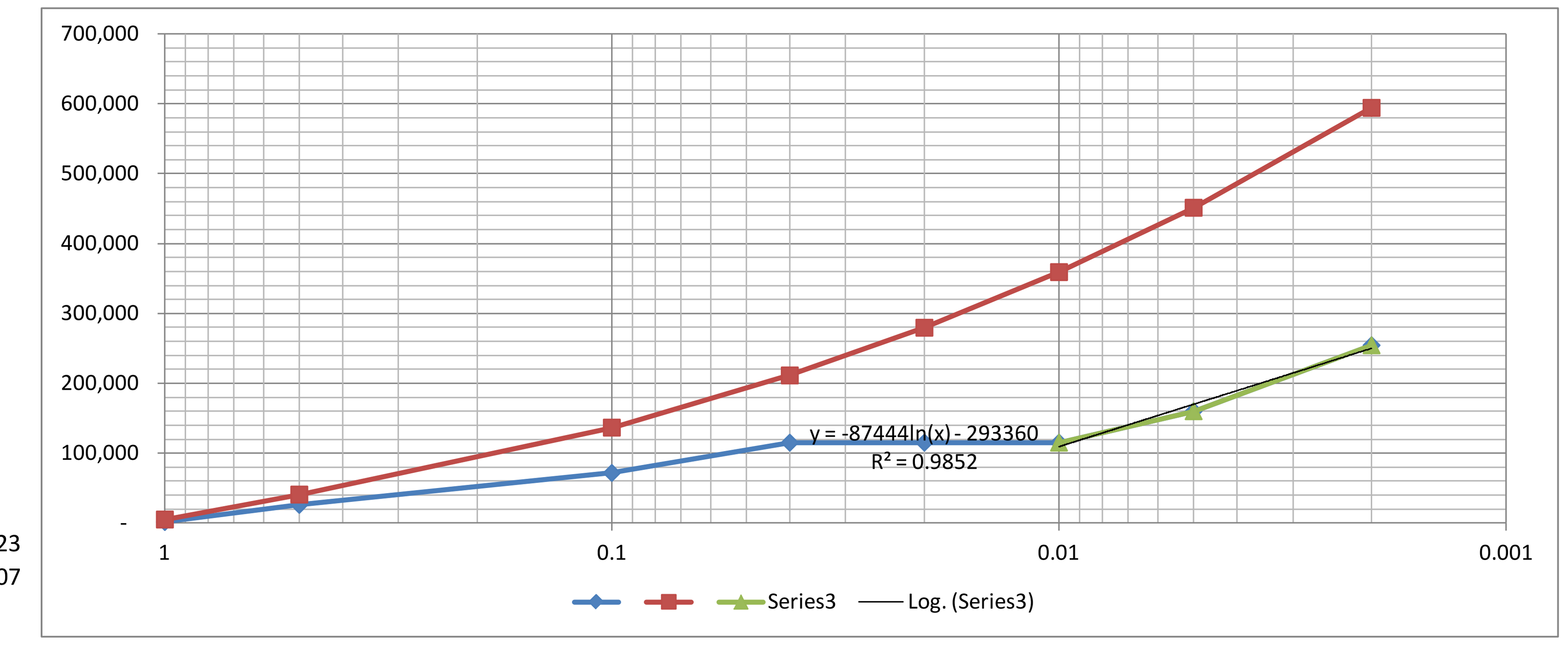

0.01	115,000
0.005	160,000
0.002	254,357

200	0.005	169,946	
225	0.004444	180,245	
250	0.004	189,459	180,000
325	0.003077	212,401	
400	0.0025	230,558	
500	0.002	250,070	

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-87444 293360

F3 (Without-Project) Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

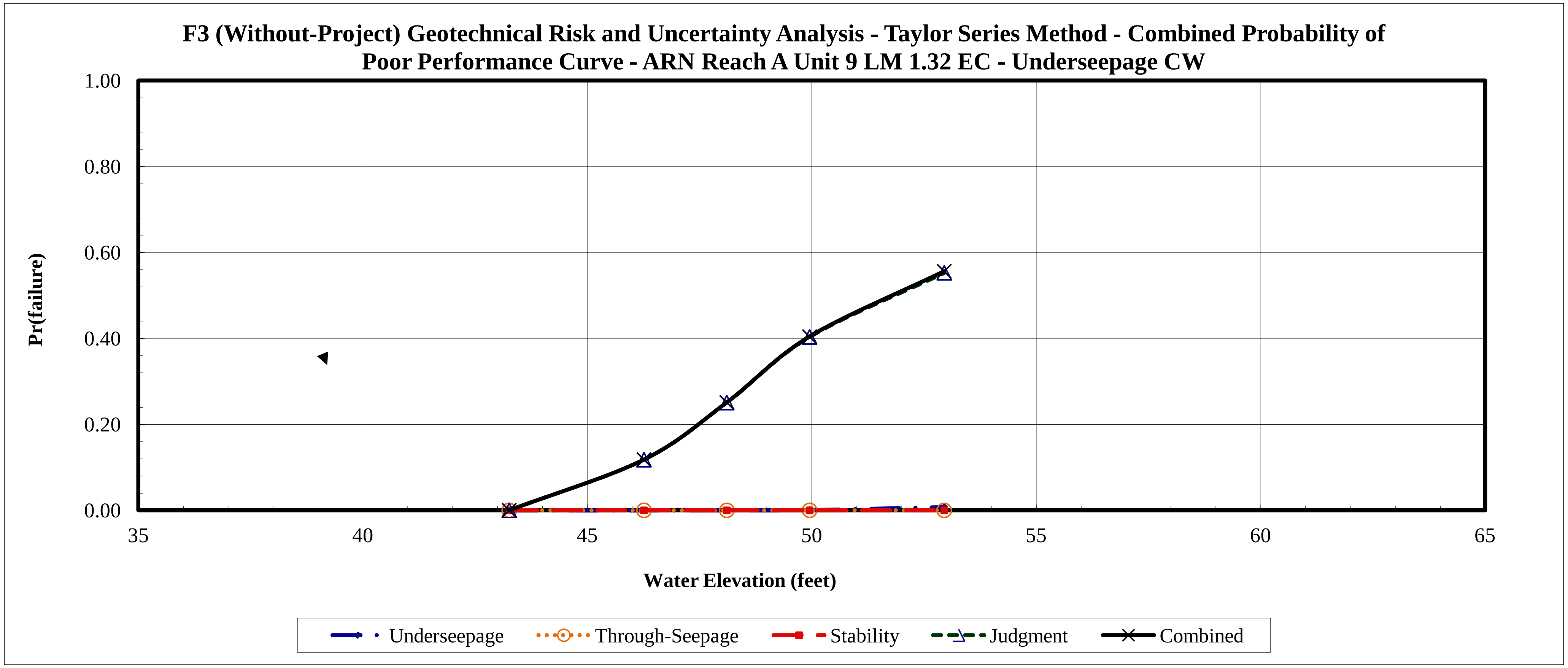
Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case: EC - Underseepage CW

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1179	0.8821	0.1179	0.8821
48.11	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.2507	0.7493	0.2509	0.7491
49.95	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.4036	0.5964	0.4042	0.5958
52.95	0.0076	0.9924	0.0000	1.0000	0.0000	1.0000	0.5528	0.4472	0.5562	0.4438



F3 (Without-Project) Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

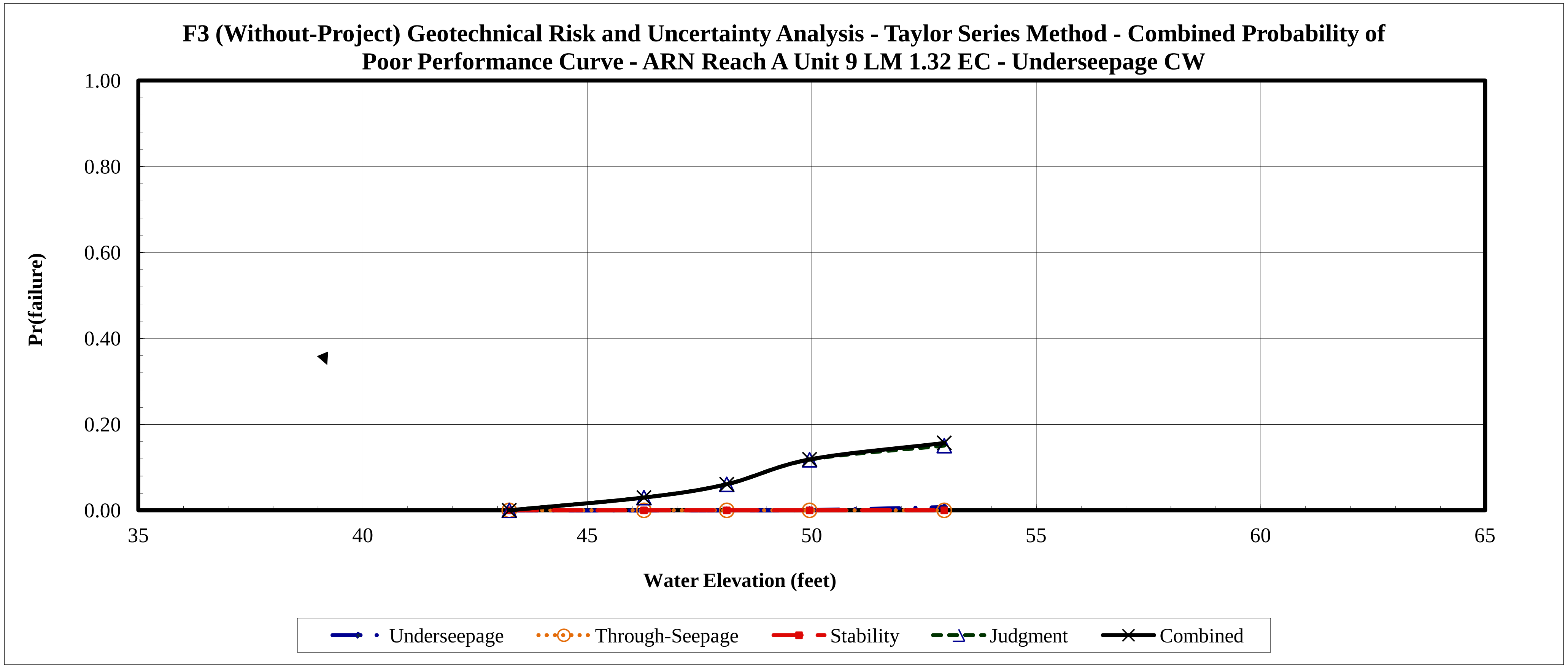
Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case: EC - Underseepage CW

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0297	0.9703
48.11	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.0606	0.9394	0.0607	0.9393
49.95	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.1178	0.8822	0.1186	0.8814
52.95	0.0076	0.9924	0.0000	1.0000	0.0000	1.0000	0.1506	0.8494	0.1570	0.8430



F3 (Without-Project) Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

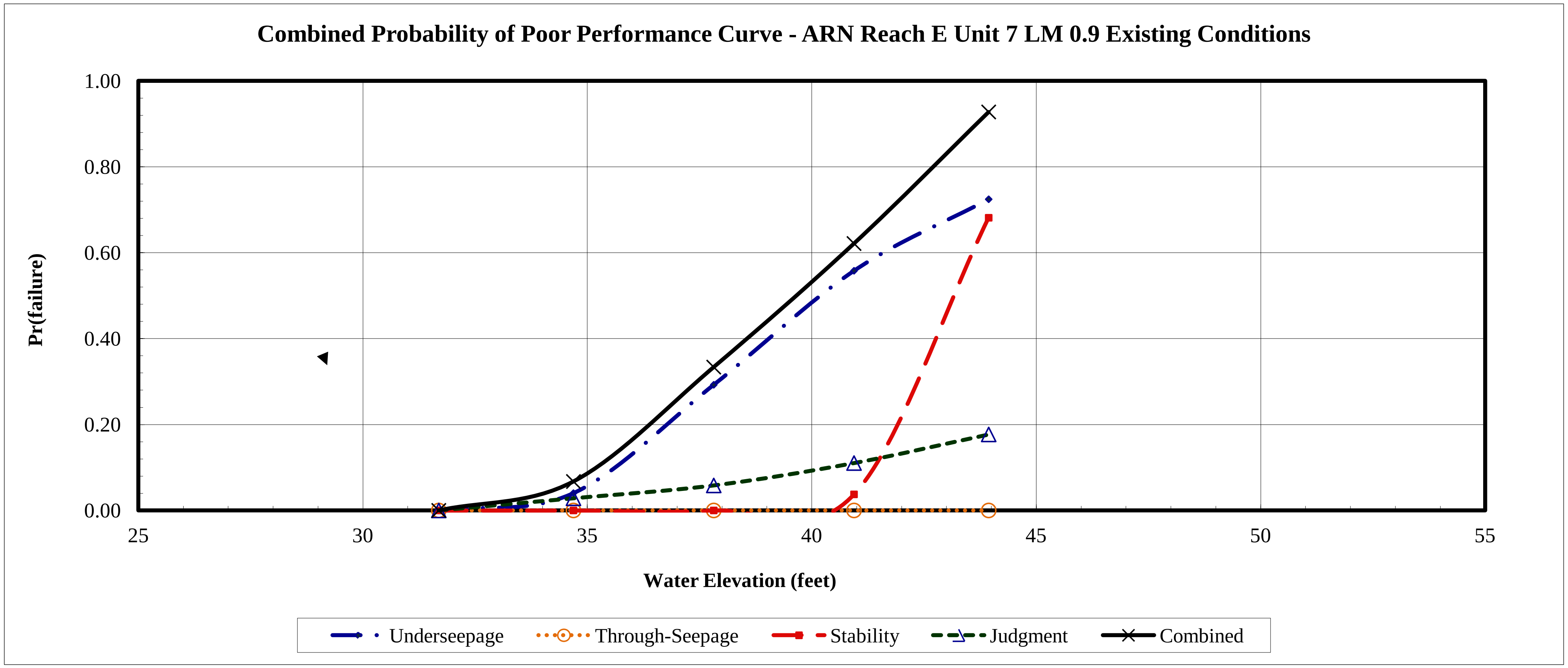
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case: Existing Conditions

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.69	0.0403	0.9597	0.0000	1.0000	0.0000	1.0000	0.0282	0.9718	0.0674	0.9326
37.82	0.2925	0.7075	0.0000	1.0000	0.0000	1.0000	0.0582	0.9418	0.3337	0.6663
40.94	0.5580	0.4420	0.0000	1.0000	0.0374	0.9626	0.1103	0.8897	0.6215	0.3785
43.94	0.7245	0.2755	0.0000	1.0000	0.6814	0.3186	0.1769	0.8231	0.9278	0.0722



F3 (Without-Project) Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

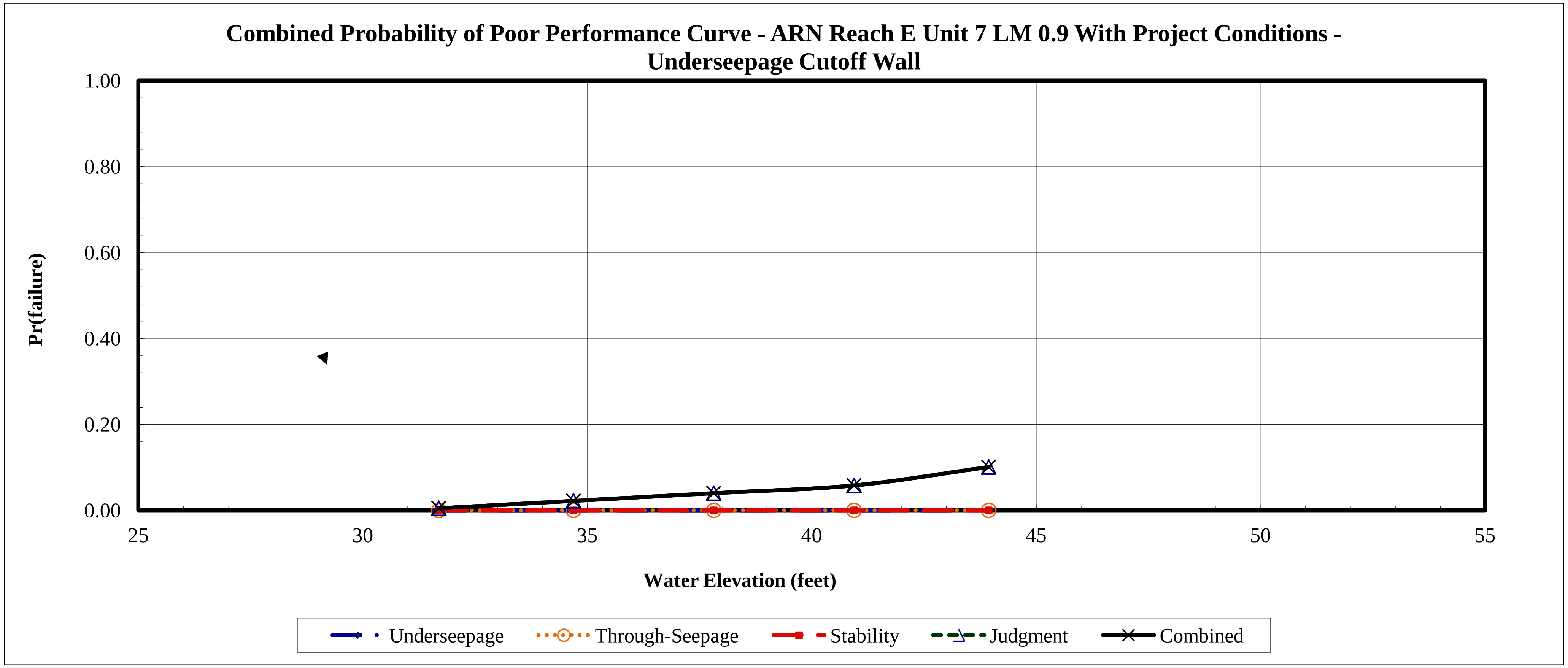
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case: With Project Conditions - Underse

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0050	0.9950	0.0050	0.9950
34.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0222	0.9778	0.0222	0.9778
37.82	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0401	0.9599	0.0401	0.9599
40.94	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0581	0.9419	0.0581	0.9419
43.94	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1009	0.8991	0.1009	0.8991



American River Common Features GRR
Attachments to Economic Appendix

Attachment 2 – Certified Construction Cost Estimates for Alternatives 1 & 2.

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

SPK - PN 149827
American River Common Features GRR
Sacramento, CA

The American River Common Features GRR, as presented by the Sacramento District, has undergone a successful Cost Agency Technical Review (Cost ATR) of remaining costs, performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the cost products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of December 3, 2015, the Cost MCX certifies the estimated total project costs:

Alternative 1 - NED Plan:

Total First Costs:	$1,343,992,000 (Cost ATR Certified) *
Fully Funded Costs:	$1,597,400,000 *

Alternative 2 - LPP Plan:

Total First Costs:	$1,565,750,000 (Cost ATR Certified) *
Fully Funded Costs:	$1,851,993,000 *

* Spent Costs Not Included. “Per direction from HQUSACE, the proposed elements of the American River Common Features GRR should be considered separate from the previously authorized portions including the work constructed using the WRDA 1996 and 1999 authorities as well as the Natomas levee improvements authorized by WRDDA 2014. Both cost sharing and the Section 902 limit would be established individually for the WRDA 96/99 features, for the WRRDA 2014 features, and for the GRR recommended plan.”

Note: Cost ATR was devoted to remaining work. It did not review spent costs, which requires an audit process. It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

JACOBS.MICHAEL.PIERRE.1160569537

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DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=JACOBS.MICHAEL.PIERRE.1160569537
Date: 2015.12.03 09:29:54 -08'00'

Kim C. Callan, PE, CCE, PM
Chief, Cost Engineering MCX
Walla Walla District

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO: P2 # 149827
LOCATION: Sacramento, CA

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

This Estimate reflects the scope and schedule in report; Feasibility Report

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
							Program Year (Budget EC): 2016									
							Effective Price Level Date: 1 OCT 15				Spent Thru:					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	**10/1/2014** ($K)	**TOTAL FIRST COST** ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***		***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***				***M***	***N***	***O***
02	RELOCATIONS *		$101,612	$27,435	27%	$129,048	0.8%	$102,411	$27,651	$130,062	$0	$130,062	22.8%	$125,718	$33,944	$159,661
06	FISH & WILDLIFE FACILITIES	Construction	$19,020	$5,135	27%	$24,156	0.4%	$19,103	$5,158	$24,261	$0	$24,261	20.5%	$23,017	$6,215	$29,232
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$48,413	$13,071	27%	$61,484	0.4%	$48,624	$13,128	$61,752	$0	$61,752	15.1%	$55,972	$15,112	$71,084
11	LEVEES & FLOODWALLS	Levees	$298,680	$80,643	27%	$379,323	0.4%	$299,871	$80,965	$380,836	$0	$380,836	17.3%	$351,674	$94,952	$446,626
16	BANK STABILIZATION		$292,672	$79,021	27%	$371,694	1.8%	$297,828	$80,414	$378,242	$0	$378,242	14.7%	$341,678	$92,253	$433,931
	CONSTRUCTION ESTIMATE TOTALS:		$760,397	$205,307		$965,705	1.0%	$767,837	$207,316	$975,153	$0	$975,153	17.0%	$898,059	$242,476	$1,140,535
01	LANDS AND DAMAGES		$88,537	$38,715	44%	$127,253	0.6%	$89,028	$38,930	$127,958	$0	$127,958	12.8%	$100,492	$43,908	$144,399
30	PLANNING, ENGINEERING & DESIGN *		$119,772	$32,338	27%	$152,110	2.3%	$122,529	$33,083	$155,611	$0	$155,611	27.6%	$156,388	$42,225	$198,613
31	CONSTRUCTION MANAGEMENT *		$59,291	$16,009	27%	$75,300	2.3%	$60,656	$16,377	$77,033	$0	$77,033	35.8%	$82,356	$22,236	$104,592
18	CULTURAL RESOURCE PRESERVATION		$6,550	$1,768	27%	$8,318	0.8%	$6,486	$1,751	$8,237	$0	$8,237	12.4%	$7,292	$1,969	$9,260
	PROJECT COST TOTALS:		$1,034,548	$294,138	28%	$1,328,686		$1,046,535	$297,457	**$1,343,992**	$0	**$1,343,992**	18.9%	$1,244,586	$352,813	$1,597,400

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CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	**65%**	**$1,038,310**
ESTIMATED NON-FEDERAL COST:	**35%**	**$559,090**
ESTIMATED TOTAL PROJECT COST:		**$1,597,400**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.

for

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT NO: P2 # 149827
LOCATION: Sacramento, CA

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

This Estimate reflects the scope and schedule in report; Feasibility Report

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
							Program Year (Budget EC): 2016 / Effective Price Level Date: 1 OCT 15				Spent Thru:	TOTAL FIRST				
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
02	RELOCATIONS *		$122,813	$34,388	28%	$157,201	0.8%	$123,779	$34,658	$158,437	$0	$158,437	21.4%	$150,279	$42,078	$192,357
06	FISH & WILDLIFE FACILITIES	Construction	$19,020	$5,326	28%	$24,346	0.4%	$19,103	$5,349	$24,452	$0	$24,452	20.5%	$23,017	$6,445	$29,462
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$55,826	$15,631	28%	$71,457	0.4%	$56,069	$15,699	$71,768	$0	$71,768	14.7%	$64,294	$18,002	$82,297
08	ROADS, RAILROADS & BRIDGES		$20,073	$5,620	28%	$25,693	0.4%	$20,155	$5,643	$25,798	$0	$25,798	5.1%	$21,192	$5,934	$27,126
11	LEVEES & FLOODWALLS	Levees	$362,348	$101,458	28%	$463,806	0.4%	$363,794	$101,862	$465,656	$0	$465,656	16.6%	$424,199	$118,776	$542,975
16	BANK STABILIZATION		$292,672	$81,948	28%	$374,620	1.8%	$297,828	$83,392	$381,220	$0	$381,220	14.7%	$341,678	$95,670	$437,347
15	FLOODWAY CONTROL & DIVERSION STRUCTURE		$42,316	$11,849	28%	$54,165	0.4%	$42,501	$11,900	$54,401	$0	$54,401	13.9%	$48,391	$13,549	$61,941
	CONSTRUCTION ESTIMATE TOTALS:		$915,069	$256,219		$1,171,289	0.9%	$923,228	$258,504	$1,181,732	$0	$1,181,732	16.2%	$1,073,050	$300,454	$1,373,504
01	LANDS AND DAMAGES		$71,078	$24,255	34%	$95,333	0.6%	$71,472	$24,389	$95,862	$0	$95,862	14.2%	$81,345	$28,148	$109,494
30	PLANNING, ENGINEERING & DESIGN *		$142,464	$39,890	28%	$182,354	2.3%	$145,743	$40,808	$186,551	$0	$186,551	25.4%	$182,808	$51,186	$233,994
31	CONSTRUCTION MANAGEMENT *		$71,303	$19,965	28%	$91,268	2.3%	$72,944	$20,424	$93,368	$0	$93,368	34.7%	$98,235	$27,506	$125,741
18	CULTURAL RESOURCE PRESERVATION		$6,550	$1,768	27%	$8,318	0.8%	$6,486	$1,751	$8,237	$0	$8,237	12.4%	$7,292	$1,969	$9,260
	PROJECT COST TOTALS:		$1,206,465	$342,097	28%	$1,548,562		$1,219,873	$345,877	**$1,565,750**	$0	**$1,565,750**	18.3%	$1,442,730	$409,263	$1,851,993

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CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	**56%**	**$1,038,310**
ESTIMATED NON-FEDERAL COST:	**44%**	**$813,683**
ESTIMATED TOTAL PROJECT COST:		**$1,851,993**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.

American River Common Features GRR
Attachments to Economic Appendix

Attachment 3 - Other Social Effects (OSE) & Regional Economic Development (RED) Analyses

ATTACHMENT 3
AMERICAN RIVER COMMON FEATURES GRR
ECONOMICS APPENDIX
OTHER SOCIAL EFFECTS (OSE) & REGIONAL ECONOMIC DEVELOPMENT (RED)
DECEMBER 2015

A. INTRODUCTION

In the past, planning studies at the Corps of Engineers have focused primarily on the National Economic Development (NED) account to formulate and evaluate water resource infrastructure projects. In recent years, however, there has been a renewed emphasis on considering the Other Social Effects (OSE), Regional Economic Development (RED), and Environmental Quality (EQ) accounts when making investment decisions, as can be seen in the publication of Engineering Circular (EC) 1105-2-409, "Planning in a Collaborative Environment." EC 1105-2-409 encourages the use of all four accounts in order to develop water resource solutions that are more holistic and acceptable, and which take into account both national and local stakeholder interests.

The following sections describe the OSE and RED assessments developed for the American River Common Features GRR. (The EQ assessment is described in the main planning document.)

B. OTHER SOCIAL EFFECTS (OSE)

Purpose and Methodology

The OSE assessment is intended to provide a portrait of the social landscape of the American River Common Features study area and offer a glimpse into the potential vulnerability of the people that live there. In essence, the questions the OSE account tries to answer are:

How are social connectedness, community social capital, and community resiliency likely to change in the absence of a solution to a water resource issue? How are vulnerable populations likely to be affected?

The metrics commonly used to answer these questions include:

- Social connectedness, which can be described using gender, race and ethnicity, age, rural versus urban communities, rental versus owner-occupied dwellings, and occupation
- Community social capital, which can be described using education, family structure, rural vs. urban communities, and population growth
- Community resilience, which can be described using income, political power, neighborhood prestige, employment loss, residential property characteristics, infrastructure and lifelines, family structure, and medical services

The assessment compares the other social effects associated with the without-project and with-project conditions. The 1% annual chance exceedance (ACE) floodplain serves as the baseline to assess effects.

References

- *Planning Guidance Notebook* (ER 1105-2-100)
- *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (IWR 09-R4)
- *Planning in a Collaborative Environment*, (EC) 1105-2-409
- *Levee Screening Tool: Methodology and Application* (November 2011, RMC-CPD-1)
- *Social Vulnerability to Environmental Hazards (*Social Science Quarterly, Volume 84, Number 2, June 2003)
- *Economic Reevaluation Report, American River Watershed Project, CA, Folsom Dam Modification and Folsom Dam Raise Projects, Appendix D-Attachment V, Other Social Effects (May 2007)*

Early History of the Sacramento Area

The area that is now Sacramento was once inhabited, possibly for thousands of years, by the Nisenan (Southern Maidu) and Plains Miwok Native Americans. Sadly, there is little evidence of their existence in the area.

Gabriel Moraga, who was a Spanish explorer, is credited with naming the Sacramento Valley and the Sacramento River sometime near the turn on the 19th century. In 1839, pioneer John Sutter came from Liestal, Switzerland with other settlers and established a trading colony and stockade (Sutter's Fort) as New Helvetia (or "New Switzerland") soon after his arrival. In 1847, Sutter received 2,000 fruit trees, which marked the beginning of the Sacramento Valley's agricultural industry.

The town's population began to increase as more people came to the area in seek of gold, first discovered by James W. Marshall in 1848 at Sutter's Mill in the town of Coloma, which is about 50 miles northeast of Sutter's Fort (in what is now the mid-town area of Sacramento). John Sutter, Jr., along with Sam Brannan, planned the City of Sacramento and named it after the Sacramento River primarily for commercial reasons. They hired William H. Warner, who was a topographical engineer, to draft the official layout of the city. The boundary of the original city layout extended from C Street in the north to Broadway Avenue in the south and to Front Street in the west to Alhambra Boulevard in the east. Today, the city of Sacramento also includes many adjacent suburbs north (across the American River), east, and south of the original city boundary. In 1849, a city charter was adopted by the citizens, and in 1850 the charter was recognized by the State legislature. Sacramento became the first incorporated city in the state of California.

The capital of California under Spanish (and then Mexican) rule had been Monterey. The capital then moved several times – first to San Jose (1851), then to Vallejo (1852), then to Benicia (1853), and then finally to Sacramento (1854), which was named the permanent state capital in 1879. With a new status and a strategic location, the city of Sacramento quickly prospered. Most significantly, it became the western end of the Pony Express as well as the western terminus of the First Transcontinental Railroad.

The city of Sacramento has a long history of flooding. In 1850 and 1861 devastating floods crippled the city causing widespread disease such as cholera and the flu. Between 1862 and the mid-1870s, the City of Sacramento raised the level of its downtown to protect itself from flooding by building reinforced brick walls and filling the resulting street walls with dirt. What used to be the first floor of buildings had now become its basements. (This perhaps may have been the first major non-structural flood risk management project in the city?)

Ironically, the same two rivers that devastated the city in the past would also prove to be key elements in the economic success of the city as commerce on both the Sacramento and American Rivers increased. The city effectively controlled the commerce on the rivers and benefitted from levying taxes on the goods unloaded from the boats. The tax income helped to fund many public works projects in the city.

The city has grown tremendously since the early days of the 1800s. In 1850, the population of the city was around 6,820. Today, the population in the city is over 475,000. The entire Sacramento metropolitan area is home to about 2.2 million people.

Current Social Landscape

Describing the social landscape of the area provides an understanding of who lives in the study area, who has a stake in the problem or issue, and why it is important to them. A demographic profile of the area is performed using social statistics, and the information is presented in a meaningful way through the use of comparisons and rankings. It is important to note that the profile itself is not an OSE analysis but rather a data collection step that provides a basic level of understanding about the social conditions in the area; the data provides input into a more in-depth analysis that targets areas of special concern or relevance to the water resources issue at hand. The basic social statistics discussed below and listed in Table 1 are indicators used to portray basic information about the social life and the processes of the study area.

The city of Sacramento, which lies within the American River Common Features study area, is home to nearly half a million people; the greater metropolitan statistical area (Sacramento/Arden/Arcade/Roseville), which includes Sacramento, Yolo, Placer, and El Dorado counties, is home to approximately 2.2 million people. The region has experienced tremendous growth over the last 10 to 15 years as an influx of people have moved to the area to take advantage of the relatively affordable home prices as well as the many amenities the region has to offer. Between 2000 and 2010, the city of Sacramento experienced a population increase of about 15%. The people that have moved here over the years represent many different races and ethnicities, bringing increased diversity to the area. For example, the city has seen an increase of about 15% and 25% in the Asian and Hispanic populations, respectively. This increase in the Asian and Hispanic populations may also explain the increase in the percentage of people who speak a language other than English at home; this percentage has increased approximately 13%, from about 33% of the population in 2000 to about 37% in 2010.

Additionally, based on the 2010 Census, the people that have settled in the area over the past decade have achieved greater levels of formal education, with about 29% having at least a bachelor's degree (compared to only about 24% in 2000); this is an increase of approximately 23%.

Finally, between the 2000 and 2010 Census, the data indicate that the city has experienced increased poverty and unemployment, more so than the state of California as a whole. In 2010, the unemployment rate in the city was nearly 14%, which is almost three times higher than in 2000 (4.7%). At the same time, the percentage of people living below the poverty level also increased from about 15.3% in 2000 to over 20% in 2010. Since the 2010 Census, however, the economy in the region has improved significantly and the unemployment rate has come down.

Key statistics are presented in Table 1 below.

Table 1: Basic Social Characteristic of the American River Common Features Study Area - 2000 and 2010 Census Data

Social Statistic	Sacramento			California		
	2000	2010	% Δ	2000	2010	% Δ
Population	407,018	466,488	+15%	33,871,648	37,253,956	+10%
Age						
Median	32.8	33	+1%	33.3	35.2	+5.7%
% >65	11.4%	10.6%	-7%	10.6%	11.4%	+7.5%
% <18	27.3%	24.9%	-8.8%	27.3%	25.0%	-8.4%
Race & Ethnicity						
Asian	16.6%	18.3%	+10%	10.9%	12.8%	+17.4%
Black	15.5%	14.6%	-7%	6.7%	5.8%	-13.4%
Hispanic	21.6%	26.9%	+24.5%	32.4%	37.6%	+16%
White	40.5%	34.5%	-15%	46.7%	40.1%	-14.1%
Other	5.8%	5.7%	-1.8%	4.3%	3.7%	+86%
Education						
% HS Graduates	77.3%	82.1%	+6.2%	81%	80.8%	-0.2%
% College Graduates	23.9%	29.4%	+23%	30.5%	30.2%	-0.9%
Income and Poverty						
% Unemployed	4.7%	13.9%	+296%	4.3%	7.1%	+65%
Median Household Income	37,049	50,661	+36.7%	$61,400	$61,632	0%
% Below Poverty	15.3%	20.2%	+32%	15.3%	14.4%	-5.9%
Housing						
% Own	50.1%	49.4%	-1.4%	56%	55.9%	0%
% Rent	49.9%	50.6%	+1.4%	44%	44.1%	0%
Quality of Life						
Avg. Household Size	2.65	2.68	+1%	2.98	3.45	+16%
Language Other than English Spoken at Home	32.6%	36.8%	+12.9%	43.5%	43.2%	-0.7%
Mean Travel Time to Work (in minutes)	23.4	23.7	+1.3%	27.1	27	-0.4%

Social Effects Assessment

A social effects assessment considers the social vulnerability and resiliency of a population. Social vulnerability refers to the sensitivity of a population to natural hazards, whereas social resiliency refers to the population's ability to respond to and recover from the impacts of a natural hazard. The characteristics that are recognized as having an influence on social vulnerability and resiliency generally include age, gender, race, and socioeconomic status as well as population segments with special needs or those without the normal social safety nets typically necessary to recover from a disaster. The quality of human settlements (e.g., housing type and construction, infrastructure, and lifelines) and the built environment also play an important role in assessing social vulnerability and resiliency, especially as these characteristics influence potential economic losses, injuries, and fatalities from natural hazards. Table 2 provides a discussion of factors that may influence social vulnerability and resiliency and also provides a qualitative assessment of the American River Common Features study area based on indicator statistics from the 2010 U.S. Census. The discussion column in Table 2 is from the article, *Social Vulnerability to Environmental Hazards*, which was published in the June 2003 edition of Social Science Quarterly.

Table 2: Social Vulnerability and Resiliency Indicators – Sacramento Study Area Assessment

Indicator	Discussion	Assessment
Income, political power, and prestige	This measure focuses on the ability to absorb losses and enhance resilience to hazard impacts. Wealth enables communities to absorb and recover from losses more quickly due to insurance, social safety nets, and entitlement programs.	The median household income of the area is below the median for the state of California; however, the city is the state's Capital and has access to significant amount of political resources.
Gender	Women can have a more difficult time during recovery than men, often due to sector-specific employment, lower wages, and family care responsibilities.	Women make up 49.4% of the work force while men make up 50.6%; the median income for women in the area is $42,824, which is 89% of the median income for men.
Race and Ethnicity	Race and ethnicity may impose language and cultural barriers that affect access to post-disaster funding	The area is highly diverse in terms of race and ethnicity. Over one-third of the residents speak a language other than English at home; this may contribute to the vulnerability and possibly the resiliency of the community.
Age	Extremes on the age spectrum inhibit the movement out of harm's way. Parents lose time and money caring for children when daycare facilities are affected; the elderly may have mobility constraints or mobility concerns increasing the burden of care and lack of resilience.	Those age 65 and over make up a slightly lower percentage of the community's population as compared to the percentage for the state as a whole; the percentage of residents younger than 18 (24.9%) is about the same as the state statistic (25%).
Employment Loss	The potential loss of employment following a disaster exacerbates the number of unemployed workers in a	The latest Census indicates that the current unemployment rate in the area may be significantly higher

	community, contributing to a slower recovery from the disaster.	than the state's. A flood event which causes additional unemployment may exacerbate the current unemployment rate.
Rural/Urban	Rural residents may be more vulnerable due to lower incomes, and may be more dependent on locally-based resource extraction economies (farming and fishing). High-density areas (urban) complicate evacuation from harm's way.	The area is highly urbanized and close to many resources.
Residential Property	The value, quality, and density of residential construction affect potential losses and recovery. For example, expensive homes are costly to replace, while mobile homes are easily destroyed and less resilient to hazards.	The area is comprised of a full spectrum of homes – from average quality to excellent. Medium density neighborhoods are typical, with higher density neighborhoods in the downtown/midtown area.
Infrastructure and Lifelines	Loss of sewers, bridges, water, communications, and transportation infrastructure may place an insurmountable financial burden on the smaller communities that lack the financial resources to rebuild.	Most of the neighborhoods within the study area are well-established and would most likely have access to the many resources available within the city itself as well as within the greater metropolitan area, which includes, Davis, West Sacramento, Folsom, Elk Grove, Dixon, and many other cities.
Renters	People that rent typically do so because they are either transient or do not have the financial resources for home ownership. They often lack access to information about financial aid during recovery. In the most extreme cases, renters lack sufficient shelter options when lodging becomes uninhabitable or too costly to afford.	The number of rentals in the area is significant (about 51%), and is higher than the state average of about 44%. The high rental population may contribute to communication cohesion issues; research indicates that renters do not have the same level of community pride as owners do, which may lead to more challenges in redeveloping a community after a flood event.
Occupation	Some occupations, especially those of resource extraction, may be severely impacted by a hazard event. Self-employed fishermen suffer when their means of production is lost and may not have the requisite capital to resume work in a timely fashion and thus will seek alternative employment. Migrant workers engaged in agriculture and low skilled service jobs (e.g., housekeeping, childcare,	The number of people that live in the area and work in resource extraction occupations is fairly low; the 2010 Census indicates that around 1,226 people (or 0.6% of the total work force) work in the farming, fishing, and forestry occupations.

	and gardening) may similarly suffer, as disposable income fades and the need for services decline. Immigration status also affects occupational recovery.	
Family Structure	Families with large numbers of dependents or single-parent households often have limited finances to outsource care for dependents, and thus must juggle work responsibilities and care for family members. All affect the resilience to recover from hazards.	The literature indicates that families having greater than four persons have more financial difficulty than smaller families. Accordingly, community planners need to be aware of issues that may arise.
Education	Education is strongly linked to socioeconomic status, with higher educational attainment resulting in greater lifetime earnings. Lower education constrains the ability to understand warning information and access to recovery information.	Over 80% of the population has graduated from high school and almost a third of the population hold a bachelor's degree.
Population Growth	Counties experiencing rapid growth lack available quality housing; its social services network may not have had time to adjust to increased populations. New migrants may not speak the language and not be familiar with bureaucracies for obtaining relief or recovery information, all of which increases vulnerability.	Sacramento has grown significantly over the past fifteen years, with a majority of the growth taking place between 2000 and 2010. The growth rate between 2000 and 2010 was about 15%. Overall, growth has been significant but not rapid; there are parts of the city that have experienced rapid growth (e.g., Natomas). Rapid growth is highly correlated with low community cohesion. The sense of belonging, cooperation, and community pride are dynamic factors which help with community resilience but which may not be as strong in cities that have experienced rapid growth.
Medical Services	Health care providers, including physicians, nursing homes, and hospitals are important post-event sources of relief. The lack of proximate medical services will lengthen immediate relief and result in longer recovery from disasters.	The residents of Sacramento would have access to nearby medical facilities in the cities of Davis, Woodland, West Sacramento, Elk Grove, Folsom, El Dorado Hills, Roseville, Rocklin, Dixon, and others

Life Safety Evaluation

The Sacramento District's Levee Safety Section uses the Levee Screening Tool (LST) to assess levees within the District's geographic boundary. The LST provides an initial quantitative risk estimate to assist local, state, and federal stakeholders in identifying and prioritizing the funding needs for levees of concern. The information and data entered into the LST are collected from existing information/data. Life loss estimates are computed in the LST based on the information/data entered and for various scenario/conditions, including life loss during the day time, life loss during the night time, life loss assuming a levee breach prior to overtopping, and life loss assuming no breach until overtopping. Additional information about the levee screening tool and its computation processes can be found in, *Levee Screening Tool: Methodology and Application,* as listed in the reference section.

The results of the levee screenings performed for the American River Common Features study area were used in this OSE assessment to make preliminary estimates of life loss. The results of two scenarios modeled in the LST, levee breach prior to overtopping and no levee breach until overtopping, are presented here. For this assessment, the levee breach prior to overtopping scenario was assigned to the without-project condition and the no levee breach until overtopping was assigned to the with-project (Alternatives 1 and 2) conditions. A comparison of potential fatalities under each condition and for various levee segments within the system is displayed in Table 3 below.

Table 3: Statistical Life Loss Estimates

Levee Segment/Impact Area	Estimated Life Loss					
	Without-Project (Assumes Breach Prior to Overtopping)			Alternative 1/Alternative 2 (Assumes No Breach Until Overtopping)		
	Day	Night	Weighted	Day	Night	Weighted
Natomas Cross Canal – Left Bank (Natomas)	669	553	605	221	183	200
Arcade Creek – Left Bank (ARN)	166	151	158	95	86	90
NEMDC – Left Bank (ARN)	164	149	156	94	85	89
American River – Right Bank (ARN)	170	156	163	97	89	93
American River – Left Bank (ARS)	503	978	764	166	461	328
Sacramento River – Left Bank (ARS)	595	1,128	888	281	645	481

In addition to life loss estimates, other metrics were used to assess the vulnerability of individuals living in the study area, as listed in Table 4 below.

In any assessment that relies on assumptions, there is uncertainty. The life loss estimates under the with-project condition shown in Table 3 above assume no levee breach until overtopping. Importantly, while the Levee Screening Tool (LST) does not compute probabilities of a potential levee breach, the economic model (HEC-FDA) used in the National Economic Development (NED) Analysis does compute the annual exceedance probabilities (AEP) under without-project and with-project conditions using available engineering data. These probabilities can be tied to the life loss estimates computed in the LST in order to provide a more complete picture of the overall flood risk (consequence and chance). For example, the HEC-FDA results indicate that in the ARS Basin, there is about a 1 in 147 chance of flooding in any given year under the with-project condition, which can be tied to the estimated life loss of between 328 and 481 shown in Table 3. For the ARN Basin, the HEC-FDA results indicate that there is about a 1 in 172 chance of flooding in any given year under the with-project condition, which can be tied to the estimated life loss of between 89 and 93 displayed in Table 3. In both basins, the chance of flooding and therefore life loss is significantly reduced with a project in place as compared to without a project in place. (Under without-project conditions, the chance of flooding in any given year in the ARS and ARN Basins are about a 1 in 32 and 1 in 61, respectively.)

Table 4: Description of Metrics Used to Evaluate Life Safety

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE floodplain based on the 2010 census block GIS data.
Critical Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, and jails that are of life safety significance; also includes substations, schools, power plants, chemical industry, colleges, intermodal shipping, heliports, petroleum bulk plants, and broadcast communication which may be of regional significance
Evacuation Routes (Number of Routes)	Assesses the vulnerability of populations with regard to the number of escape routes available during flood events.
Wise Use of Floodplains (Acres)	Potentially developable land within the 0.2% ACE floodplain. Acres of land with 1% ACE flood depths less than 3 feet.

Table 5 displays the comparison for the without-project and with-project (Alternatives 1 and 2) conditions as they relate specifically to the life safety metrics summarized in Table 4.

Table 5: Summary of Life Safety Metrics

Evaluation Metric	Alternative	
	Without-Project	Alternative 1/Alternative 2
Population at Risk (People)	250,000	0
Critical Infrastructure (Facilities)	523	0
Evacuation Routes (Number of Routes)	43	43
Wise Use of Floodplains (Acres)	0	TBD

[1]Values based on 1% ACE event floodplain

Population at Risk: The population at risk of flooding from a 1% ACE flood event is about 250,000 for the without-project condition. Most of this population would be removed from the 1% ACE floodplain under either Alternative 1 or 2. Of special concern is the population segment over the age of 65 living within the study area since these individuals have been shown to be at higher risk of life loss from flood events. The Sacramento community's senior population is slightly lower (10.6% of total population) than the senior population of the state of California (11.4%).

Additionally, the area in the American River North (ARN) Basin benefitting from the improvements to the creeks (Arcade, Dry, Robla, and the NMDEC) represents one of the most impoverished locations in

Sacramento County.[1] In fact, the median family income in Sacramento is more than 50 percent higher than the median family income of the affected area ($55,064 compared to $35,828); the poverty rate in the affected area is 64 percent higher that of the surrounding county (29.0% compared to 17.6%). Within some parts of the affected area more than one in three family's live below the poverty line (34.1% in zip code 95815). Furthermore, these high rates of poverty are strongly correlated with disabilities, lack of car ownership and other factors that increase life safety hazards. In the absence of these improvements, the flood risk for this area would change very little, thereby putting this community at a further disadvantage relative to neighboring communities in the study area.

Critical Infrastructure: A significant amount of critical infrastructure is located within the Common Features study area. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are fire stations, police stations, hospitals, senior living facilities, and prisons.

The numerous federal, state, county, and city offices located within the inundation area could be directly impacted. The massive loss of city and state offices would severely hamper a number of critical local government functions, at least temporarily. A significant number of records, both digital and hardcopy, have the potential to be lost. Floors of high-rise buildings above the effects of floodwaters would remain relatively untouched, but the bottom floors of large office buildings and their contents would most likely be destroyed.

The disruption of government work could have major indirect impacts to people living outside of the immediate flood zone. For state offices, the effects of flooding in the state's capitol could disrupt the lives of everyone living in California. County, city, and federal offices would also incur losses. While non-essential government workers would experience temporary unemployment, it is unlikely that government work would stop completely. Indeed, after an emergency of this scale, there would likely be a large need for more government action in the form of managing aid and organizing rebuilding efforts. Government offices outside of the flood footprint, either in West Sacramento or in the eastern part of Sacramento County, would likely increase their workloads and displaced employees could most likely find temporary workspace in these offices once security issues and logistical needs are assessed and provided.

Both Alternatives 1 and 2 significantly lowers the flood risk to critical infrastructure within the study area.

Evacuation Routes: The City of Sacramento's evacuation plan was updated as of September 2008. In their plan they have identified temporary shelters with their addresses and phone numbers within the city limits. They also have detailed maps for evacuation routes based on police beats, and they have a table for different triggers and the particular activation that needs to occur based on them and the roles and responsibilities of each agency for that trigger.

The County of Sacramento's evacuation plan was updated as of November 2008. In their plan they have identified temporary shelters with their addresses within the county limits. They also have detailed maps for evacuation routes, and they have identified different triggers and the particular activation that

[1] The above analysis is based on the US Census Bureau 2009-2013 American Community Survey comparing Sacramento County to the zip codes most closely associated with the area affected by the increment (95815 and 95838).

needs to occur based on them and the roles and responsibilities of each agency for that trigger.

Both the City and County have created detailed maps for various hypothetical levee breaks. These maps identify evacuation routes, and which evacuation routes would become inundated overtime and impassible. Depending on the location of the levee breach, up to 43 evacuation routes (all basins) have been identified which include highways and freeways, and main streets/roads.

Community awareness of the flood risk is good. Flood risk and levee safety have been covered extensively over the last few years by all the local TV stations and the Sacramento Bee newspaper. Additionally, Sacramento County has emergency sirens and a reverse-911 system. The Emergency Operations and Emergency Evacuation plans discuss communication with the local media to instruct the public during emergencies.

Wise Use of Floodplains: A determination must be made as to whether the increase in potentially developable floodplain area is acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. It is important to remember that the floodplain metric used in this assessment is a simple index based on physical parameters. The metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. Those factors should be considered in conjunction with the metric.

Without-Project and With-Project Comparison

An assessment of the beneficial and adverse effects associated with the without-project condition and Alternatives 1 and 2 (with-project condition) was made. The social effects of the alternatives have both direct and indirect effects. Direct effects come from construction of the projects, whereas indirect effects come from the effects of the project on the existing social landscape. The alternatives are characterized using descriptors related to magnitude (number of individuals affected), location (concentration of effects), timing and duration (when the effects will start and how long they are expected to last), and associated risks. Table 6 provides a description of the effects of the without-project condition and Alternatives 1 and 2.

Table 6: Effects of Alternatives

	Without-Project	Alternative 1/Alternative 2
Alternative Description		
	No project is constructed by the Federal government	Improvements to the Sacramento River levees (left bank from confluence to south of Freeport), American River levees (right and left banks), East Side Tributaries, and Sacramento Bypass (Alternative 2 only) are made
Other Social Effects (OSE)		
Summary	Continued flood risk and high potential consequences in the West Sacramento study area	Life safety residual risk is significantly reduced
Population at Risk (PAR)	Approximately 250,000 people are at high risk from a 1% ACE flood	The risk from a 1% ACE flood is significantly reduced for all of the approximately 250,000 Sacramento residents
Loss of Life	Potential loss of life: 1,051	Potential loss of life: 574
Critical Infrastructure	523 critical infrastructure at risk	0 critical infrastructure at risk
Evacuation Routes	No evacuation routes available if flood event occurs	43 evacuation routes available in the event of a flood
Wise Use of Floodplains	0 available acres	About X acres of land would be available for future development
Social Vulnerability	The community may be characterized as having a medium level of social vulnerability based on the social vulnerability indicators presented in Table 2	Flood risk to the Sacramento community is reduced, and social vulnerability is minimized due to the decrease in chance of a flood occurring
Residual Risk and Consequences	Residual risk remains high throughout the study area.	Residual risk for life safety is significantly reduced.

It is important to realize that while either alternative would significantly reduce the overall flood risk to Sacramento, the risk will not be, and never will be, completely removed. In other words, while the alternatives would significantly reduce the chance of flooding, the tens of thousands of people and thousands of homes still remain susceptible to flood events which exceed the project design and the associated AEP.

C. REGIONAL ECONOMIC DEVELOPMENT (RED)

Purpose and Methodology

The U.S. Army Corps of Engineers (USACE) *Planning Guidance Notebook* (ER 1105-2-100) states that while the National Economic Development (NED) and Environmental Quality (EQ) accounts are required, display of the Regional Economic Development (RED) effects are discretionary. The Corps' NED procedures manual affirms that RED benefits are real and legitimate; however, the concern (from a Federal perspective) is that they are often offset by RED costs in other regions. Nevertheless, for the local community these benefits are important and can help them in making their preferred planning decisions.

Although the RED account is often examined in less detail than NED, it remains useful. For example, Hurricane Katrina caused a significant economic hardship to not just the immediate Gulf Coast but for entire counties, watersheds, and the state of Louisiana. Besides the devastating damage to homes (which are often captured by the NED account), hundreds of thousands of people lost their jobs, property values fell, and tourism and tax revenues declined significantly and were transferred to other parts of the U.S. In this example, the RED account can provide a better depiction of the overall impact to the region.

The distinction between NED and RED is a matter of perspective, not economics. A non-federal partner may consider the impacts at the state, regional, and local levels to be a true measure of a project's impact or benefit, whereas from the Corps' perspective, this may not constitute a national benefit. Gains in RED to one region may be partially or wholly offset by losses elsewhere in the nation. For example, if a Federal project enables a firm to leave one state to relocate to a newly-protected floodplain of another state, the increase in regional income for the project area may come at the expense of the former area's loss. In this case, there is no net increase in the value of the nation's output of goods and services and should be excluded from NED computations.

The following sections describe the impacts of Alternatives 1 and 2 from a regional perspective. The impacts were evaluated using the Corps' certified RECONS software.

Key RED Concepts

Econometric analysis allows for the evaluation of a full range of economic impacts related to specific economic activities by calculating effects of the activities in a specific geographic area. These effects are:

- Direct effects, which consist of economic activity contained exclusively within the designated sector. This includes all expenditures made by the companies or organizations in the industry and all employees who work directly for them.
- Indirect effects, which define the creation of additional economic activity that results from linked business, suppliers of goods and services, and provisions of operating inputs.
- Induce effects, which measure the consumption expenditures of direct and indirect sector employees.

Input-output (I/O) models are characterized by their ability to evaluate the effects of industries on each other. Unlike most typical measures of economic activity that examine only the total output of an industry or the final consumption demand provided by a given output, I/O models provide a much more comprehensive view of the interrelated economic impacts. I/O analysis is based on the notion that there is a fundamental relationship between the volume of output of an industry and the volume of the various inputs used to produce that output. Industries are often grouped into production, distribution, transportation, and consumption categories. Additionally, the I/O model can be used to quantify the multiplier effect, which refers to the idea that an increase in spending can lead to an even greater increase in income and consumption, as monies circulate (or multiply) throughout the economy.

Flood Risk Management RED Considerations

There are particular effects for each type of project improvement as they relate to the RED account. The estimation of RED flood-related effects can be very complex. At a minimum, the RED analysis should include a qualitative description of the types of businesses at risk from flooding, particularly those that could have a significant adverse impact (output, employment, etc.) upon the community or regional economies if their operations should be disrupted by flooding and how this would be affected by the recommended project. The potential RED effects to flood risk management projects are summarized in Table 7 below.

Table 7: Potential RED Effects to Flood Risk Management

RED Factor	Potential RED Effects
Construction	Additional construction related activity and resulting spillovers to suppliers
Revenues	Increased local business revenues as a consequence of reduced flooding, particularly from catastrophic floods
Tax Revenues	Increased income and sales taxes from the direct project and spillover industries
Employment	Short-term increase in construction employment; with catastrophic floods, significant losses in local employment (apart from the debris and repair businesses, which may show temporary gains)
Population Distribution	Disadvantage groups may benefit from the creation of a flood-free zone
Increased Wealth	Potential increase in wealth for floodplain residents as less is spent on damaged property, repairs, etc.; potential increase in property values.

RECONS Software

A variety of software programs are available to measure the RED impacts of a project. The Corps of Engineers' Institute for Water Resources (IWR) along with the Louis Berger Group has developed a regional economic impact modeling tool called Regional Economic System (RECONS) that computes estimates of regional and national job creation, retention, and other economic measures. The expenditures made by the USACE for various services and products generate economic activity that can be measured in jobs, income, sales, and gross regional product. The software automates calculations and generates estimates of economic measures associated with USACE's annual civil works program spending. RECONS was built by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations by the Minnesota IMPLAN Group. These multipliers were then imported into a database. The software ties various spending profiles to the matching industry sectors by location to produce economic impact estimates. The RECONS program is used to document the performance of direct investment spending of the USACE, and allows users to evaluate project and program expenditures associated with annual expenditures.

RECONS Inputs and Outputs

The economic impacts presented below show the Common Features study area and the state of California's interrelated economic impacts resulting from an injection of flood risk management construction funds. For this assessment, the study area and the state of California were both used as the geographic designation to assess the overall impacts to the regional economy from constructing either Alternative 1 or Alternative 2. This places a frame around the economic impacts where the activity is internalized; leakages, which are payments made to imports or value added sectors that do not in turn re-spend the dollars within the area, are not included in the total impacts.

Table 8 summarizes the complex nature of the regional economy of the Sacramento/Arden/Arcade/Roseville, CA Metropolitan Statistical Area (MSA), which includes El Dorado, Placer, Sacramento, and Yolo counties and a population of approximately 2.2 million. There are approximately 1.2 million people employed in the MSA who provide an output to the nation worth over $158 billion annually.

Table 8: Regional Profile – Sacramento/Arden/Arcade/Roseville, CA MSA (Dollar Values in $Millions, October 2015 Price Level)

Industry	Output	Labor Income	GRP	Employment
Accommodations and Food Service	$4,522	$1,562	$2,384	75,155
Administrative and Waste Management Services	$4,072	$2,145	$2,665	67,557
Agriculture, Forestry, Fishing and Hunting	$1,526	$388	$671	11,783
Arts, Entertainment, and Recreation	$1,594	$489	$751	21,054
Construction	$12,733	$5,471	$5,999	82,970
Education	$4,254	$3,367	$3,811	66,272
Finance, Insurance, Real Estate, Rental and Leasing	$23,202	$5,878	$14,551	118,760
Government	$21,059	$17,612	$19,940	241,383
Health Care and Social Assistance	$10,710	$6,058	$7,029	103,062
Imputed Rents	$12,558	$2,011	$8,153	65,011
Information	$7,646	$1,442	$3,075	20,698
Management of Companies and Enterprises	$2,040	$876	$1,172	10,242
Manufacturing	$19,269	$3,263	$4,460	39,136
Mining	$562	$129	$344	1,087
Professional, Scientific, and Technical Services	$12,918	$6,688	$7,771	89,771
Retail Trade	$9,491	$4,062	$6,519	123,095

Transportation and Warehousing	$3,686	$1,470	$2,176	27,064
Utilities	$1,103	$243	$672	1,635
Wholesale Trade	$5,344	$2,022	$3,467	30,383
Total	**$158,286**	**$65,176**	**$95,610**	**1,196,119**

Input Costs: The total remaining costs of Alternatives 1 and 2 are $1,216,034,000 and $1,469,888,000, respectively (none of the costs have been expended). The RED analysis requires the adjustment of costs for two items: (1) interest during construction (IDC) and (2) purchase of land. Interest during construction is used in the NED analysis to estimate the opportunity cost of using money for one economic endeavor (e.g., building a FRM project) instead of another (e.g., building a bullet train); IDC is not actually expended within the region and therefore is not included in the RED analysis. Similarly, the purchase of land, not including administrative costs, is considered a transfer payment from one party to another and therefore is also not included in the RED analysis.

Tables 9 and 10 are based on the average annual regional expenditures that are expected over the construction period. The construction period for Alternative 1 is assumed to be 10 years; for Alternative 2 it is also assumed to be 10 years. Over that period, a total of about $1.22 billion is anticipated to be spent in the study area if Alternative 1 is built; a total of about $1.47 billion is anticipated to be spent if Alternative 2 is built. The average construction expenditure for Alternative 1 is about $122 million, which is the anticipated amount ($1.22 billion) divided by the number of years of construction (10); the average construction expenditure for Alternative 2 is about $147 million, which is the anticipated amount ($1.47 billion) divided by the number of years of construction (10).

Table 9: Alternative 1 Inputs Assumptions, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Category	Spending	Spending Amount	Local Percentage Capture		
		Alternative 1	Local	State	National
Aggregate Materials	10%	119,171,000	70	77	97
Other Materials	1%	14,572,000	99	100	100
Equipment	35%	425,612,000	69	99	100
Construction Labor	54%	656,658,000	100	100	100
Total	100%	1,216,034,000	NA	NA	NA

Table 10: Alternative 2 Inputs Assumptions, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Category	Spending	Spending Amount	Local Percentage Capture		
		Alternative 2	Local	State	National
Aggregate Materials	10%	144,049,000	70	77	97
Other Materials	1%	17,639,000	99	100	100
Equipment	35%	514,461,000	69	99	100
Construction Labor	54%	793,739,000	100	100	100
Total	100%	1,469,888,000	NA	NA	NA

RECONS Outputs: Direct expenditures expected for construction of earthen levees are spent primarily in two sectors of the economy, construction labor and equipment (both alternatives). Both accounts for 89% of the total project expenditures. Local capture rates are computed in RECONS to show where the output from expenditures is realized. As indicated in Tables 9 and 10, all of the construction labor is expected to occur within the Sacramento/Arden/Arcade/Roseville MSA (both alternatives); 69% of the equipment is expected to be provided from within the study area and 99% from within the state of California (both alternatives).

Tables 11 and 12 summarize the overall economic impacts of Alternatives 1 and 2. The USACE is planning to expend approximately $1.35 billion if Alternative 1 is built and approximately $1.57 billion if Alternative 2 is built. Of total project expenditures, approximately $1.05 billion will be captured within the regional impact area if Alternative 1 is built and approximately $1.27 billion will be captured within the regional impact area if Alternative 2 is built. For either alternative, the rest will be leaked out to the state of California or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity, which can be measured in jobs, income, sales, and GRP as summarized in Tables 13-18 (economic activity on regional, state, and national basis). It is important to note that the RED analysis indicates that construction of either alternative is anticipated to generate over 22,000 jobs and over one billion dollars in labor income during the construction period.

Table 11: Alternative 1, Summary of Economic Impacts, Sacramento/Arden/Arcade/Roseville, CA MSA (Dollar Values in October 2015 Price Level)

Total Spending		Alternative 1		
		Regional	State	National
		$1,216,034,000	$1,216,034,000	$1,216,034,000
Direct Impact	Output	$1,049,768,000	$1,184,467,000	$1,211,673,000
	Jobs	15,940	16,400	16,570
	Labor Income	$766,076,000	$802,542,000	$814,386,000
	GRP	$866,844,000	$941,704,000	$956,797,000
Total Impact	Output	$1,929,413,000	$2,382,499,000	$3,199,443,000
	Jobs	22,090	24,530	28,940
	Labor Income	$1,066,146,000	$1,214,895,000	$1,479,975,000
	GRP	$1,400,509,000	$1,656,427,000	$2,110,406,000

Table 12: Alternative 2, Summary of Economic Impacts, Sacramento/Arden/Arcade/Roseville, CA MSA (Dollar Values in October 2015 Price Level)

Total Spending		Alternative 2		
		Regional	State	National
		$1,469,888,000	$1,469,888,000	$1,469,888,000
Direct Impact	Output	$1,268,913,000	$1,431,730,000	$1,464,617,000
	Jobs	19,260	19,830	20,040
	Labor Income	$925,999,000	$970,077,000	$984,393,000
	GRP	$1,047,802,000	$1,138,290,000	$1,156,533,000
Total Impact	Output	$2,332,189,000	$2,879,859,000	$3,867,345,000
	Jobs	26,700	29,660	34,990
	Labor Income	$1,288,710,000	$1,468,511,000	$1,788,930,000
	GRP	$1,692,872,000	$2,002,215,000	$2,550,965,000

Table 13: Alternative 1, Economic Impacts – Regional Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 1			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$46,489,000	340	$17,220,000	$22,348,000
	Wholesale trade businesses	$1,292,000	1	$492,000	$976,000
	Transport by rail	$2,799,000	1	$951,000	$1,547,000
	Transport by water	$525,000	0	$106,000	$235,000
	Transport by truck	$32,908,000	250	$14,652,000	$17,718,000
	Construction of other new nonresidential structures	$14,464,000	80	$5,830,000	$7,363,000
	Commercial & industrial machinery & equipment rental/leasing	$294,635,000	940	$70,166,000	$159,998,000
	Labor	$656,658,000	14,310	$656,658,000	$656,658,000
Total Direct Effects		$1,049,768,000	15,940	$766,076,000	$866,844,000
Secondary Effects		$879,645,000	6,160	$300,069,000	$533,665,000
Total Effects		**$1,929,413,000**	**22,090**	**$1,066,146,000**	**$1,400,509,000**

Table 14: Alternative 2, Economic Impacts – Regional Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 2			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$56,195,000	400	$20,816,000	$27,013,000
	Wholesale trade businesses	$1,562,000	1	$595,000	$1,179,000
	Transport by rail	$3,383,000	1	$1,149,000	$1,869,000
	Transport by water	$633,000	0	$128,000	$285,000
	Transport by truck	$39,777,000	310	$17,710,000	$21,416,000
	Construction of other new nonresidential structures	$17,483,000	100	$7,048,000	$8,901,000
	Commercial & industrial machinery & equipment rental/leasing	$356,141,000	1,150	$84,814,000	$193,399,000
	Labor	$793,739,000	17,290	$793,739,000	$793,739,000
Total Direct Effects		$1,268,913,000	19,260	$925,999,000	$1,047,802,000
Secondary Effects		$1,063,276,000	7,440	$362,711,000	$645,070,000
Total Effects		**$2,332,189,000**	**26,700**	**$1,288,710,000**	**$1,692,872,000**

Table 15: Alternative 1, Economic Impacts – State Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 1			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$46,489,000	340	$17,220,000	$22,348,000
	Wholesale trade businesses	$1,787,000	10	$710,000	$1,362,000
	Transport by rail	$2,799,000	10	$951,000	$1,547,000
	Transport by water	$926,000	0	$188,000	$415,000
	Transport by truck	$40,223,000	310	$17,968,000	$21,706,000
	Construction of other new nonresidential structures	$14,592,000	80	$5,884,000	$7,430,000
	Commercial & industrial machinery & equipment rental/leasing	$420,991,000	1,350	$102,962,000	$230,237,000
	Labor	$656,658,000	14,310	$656,658,000	$656,658,000
Total Direct Effects		$1,184,467,000	16,400	$802,542,000	$941,704,000
Secondary Effects		$1,198,033,000	8,130	$412,354,000	$714,723,000
Total Effects		**$2,382,499,000**	**24,530**	**$1,214,895,000**	**$1,656,427,000**

Table 16: Alternative 2, Economic Impacts – State Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 2			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$56,195,000	400	$20,816,000	$27,013,000
	Wholesale trade businesses	$2,161,000	10	$858,000	$1,646,000
	Transport by rail	$3,383,000	10	$1,149,000	$1,869,000
	Transport by water	$1,119,000	0	$227,000	$503,000
	Transport by truck	$48,620,000	380	$21,719,000	$26,238,000
	Construction of other new nonresidential structures	$17,639,000	100	$7,112,000	$8,980,000
	Commercial & industrial machinery & equipment rental/leasing	$508,874,000	1,630	$124,455,000	$278,301,000
	Labor	$793,739,000	17,290	$793,739,000	$793,739,000
Total Direct Effects		$1,431,730,000	19,830	$970,077,000	$1,138,290,000
Secondary Effects		$1,448,128,000	9,830	$498,435,000	$863,926,000
Total Effects		**$2,879,859,000**	**29,660**	**$1,468,511,000**	**$2,002,215,000**

Table 17: Alternative 1, Economic Impacts – National Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 1			
		Sales	**Jobs**	**Labor Income**	**GRP**
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$66,150,000	480	$26,276,000	$33,314,000
	Wholesale trade businesses	$1,812,000	10	$721,000	$1,381,000
	Transport by rail	$3,466,000	10	$1,176,000	$1,916,000
	Transport by water	$1,341,000	0	$273,000	$602,000
	Transport by truck	$42,662,000	330	$19,074,000	$23,036,000
	Construction of other new nonresidential structures	$14,592,000	80	$5,884,000	$7,428,000
	Commercial & industrial machinery & equipment rental/leasing	$424,990,000	1,360	$104,320,000	$232,461,000
	Labor	$656,658,000	14,310	$656,658,000	$656,658,000
Total Direct Effects		$1,211,673,000	16,570	$814,386,000	$956,797,000
Secondary Effects		$1,987,770,000	12,370	$665,591,000	$1,153,610,000
Total Effects		**$3,199,443,000**	**28,940**	**$1,479,975,000**	**$2,110,406,000**

Table 18: Alternative 2, Economic Impacts – National Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 2			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$79,939,000	570	$31,763,000	$40,269,000
	Wholesale trade businesses	$2,190,000	10	$871,000	$1,669,000
	Transport by rail	$4,190,000	10	$1,422,000	$2,315,000
	Transport by water	$1,621,000	0	$331,000	$728,000
	Transport by truck	$51,569,000	400	$23,057,000	$27,845,000
	Construction of other new nonresidential structures	$17,639,000	100	$7,112,000	$8,980,000
	Commercial & industrial machinery & equipment rental/leasing	$513,709,000	1,640	$126,097,000	$280,988,000
	Labor	$793,739,000	17,290	$793,739,000	$793,739,000
Total Direct Effects		$1,464,617,000	20,040	$984,393,000	$1,156,533,000
Secondary Effects		$2,402,728,000	14,950	$804,537,000	$1,394,432,000
Total Effects		**$3,867,345,000**	**34,990**	**$1,788,930,000**	**$2,550,965,000**

The creation of jobs in the study area is important to note. In 2010, the unemployment rate in the study area (13.9%) was higher than the state (7.1%) average; the number of jobs gained within the region demonstrates the multiplier effect of the infusion of construction funds for this project.